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domestic water supply

january 1981

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ENVIRONMENTAL ASSESSMENT

DOMESTIC WATER SUPPLY
ZION NATIONAL PARK
UTAH

Prepared by
Zion National Park
National Park Service
U.S. Department of the Interior

ENVIRONMENTAL ASSESSMENT
DOMESTIC WATER SUPPLY
ZION NATIONAL PARK AND SPRINGDALE, UTAH

AGENCY: National Park Service, Department of the Interior

ACTION: Proposed Domestic Water Supply Alternatives

SUMMARY: This document is a report detailing the possible alternative actions considered for domestic water development for Zion National Park and Springdale, Utah. It includes a statement of the problem, 11 alternative solutions to these problems, the impacts on the environment and mitigating measures for each alternative.

ADDRESS: All comments should be sent to:

Superintendent
Zion National Park
Springdale, Utah 84767

FOR FURTHER INFORMATION CONTACT:

Superintendent
Zion National Park
Springdale, Utah 84767

RECOMMENDED: John O. Lancaster — Jan 21, 1981
Superintendent — Date

APPROVED: Acting Regional Director — January 30, 1981
Date

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STATEMENT OF PURPOSE AND NEED

The community of Springdale, Utah, is located on the North Fork of the Virgin River adjacent to the south boundary of Zion National Park. Congress in 1928 passed a law giving Springdale water rights inside Zion National Park in Section 20, Township 41 South, Range 10 West. These rights were to springs in upper Oak Creek Canyon. This law (May 28, 1928, 45 Stat. 787) was later amended on July 8, 1943 (57 Stat. 389). The revision amended the law to allow Springdale to take water from certain springs in Sections 17, 22, and 27, all in Township 41 South, Range 10 West, Salt Lake Base and Meridian. Section 20 was deleted in the 1943 revision. Springdale has filed with the state of Utah a water right of .016 cubic foot per second (cfs) from springs in Sections 22 and 27 and .112 cfs from springs in Section 17. In 1970 an agreement was signed between Springdale and the National Park Service to provide Springdale with 60 gallons per minute (gpm) from the park system. Springdale pays the Park $.23 per 1,000 gallons under this agreement and the price per 1,000 gallons is renegotiated every three years. The agreement states the Park will furnish additional water from the present system to Springdale, over and above the 60 gpm required by law, when the availability of water permits. This is not to be construed as an obligation but is dependent on availability.

Approximately 17 years ago, Springdale filed for a one cfs underground water right. The town has drilled several wells in an attempt to acquire additional water. To date, the town of Springdale has segregated their water right claiming .33 cfs (148 gpm) from their wells. This leaves .67 cfs of water still to be located and proved upon. Because of the time involved and Springdale's difficulty in finding suitable water, the state of Utah has established a deadline of April 1981 by which time Springdale must produce evidence of proving up on their water right or lose it.

Since Springdale has expressed a desire to find an additional source of water to provide for anticipated growth, the city has requested assistance from Zion National Park in determining all possible alternatives to relieve their water problem.

This assessment of alternatives discusses possible solutions to Springdale's desire to acquire more water for domestic use. Eleven alternatives detailing environmental factors, impacts, costs and related issues are covered.

DESCRIPTION OF ENVIRONMENT

Zion National Park is located on the western edge of the Colorado Plateau. The Park is composed of deeply eroded canyons with high, timber covered plateaus and mesas. The North Fork of the Virgin River has carved a deep gorge for about 12 miles which eventually opens into the broader Zion Canyon surrounded by 2,000-foot high sandstone cliffs.

Zion Canyon is roughly one-half mile wide providing a narrow riparian ecosystem dependent on water for its existence. The country is semi-arid with precipitation of approximately 14.5 inches per year. Most of this moisture comes from summer thunderstorms with about one-third coming in the early months of the year as either rain or snow. The soil created from the sandstone walls of the canyon by wind and water is basically unstable and easily erodable. These soil conditions coupled with the dry air and high summer temperatures inflict severe restrictions on the plant and animal life.

The plant species are adapted to the harsh climate with some of the plants able to take advantage of the water from the river and associated springs. Annual plants usually germinate in the early spring rains and mature quickly before the dry summers come. The vegetation in the canyon is sparse; plants are spaced to take advantage of the available moisture. Only around the springs and seeps is plant life more diverse and abundant. The Fremont cottonwood is the dominant tree in the canyon with boxelder and velvet ash also common. Grasses are common on the floor of the canyon with shrubs prevailing on the drier slopes. There are four plants located in the canyon at the present time that have been proposed as threatened, but their exact locations are unknown. An endangered cactus, the purplespine hedgehog cactus (*Echinocereus engelmannii purpureus*) may be present in the canyon. The purplespine hedgehog cactus occurs in the canyon, but it is not known if this is the correct subspecies. A more complete survey is needed to adequately address this subject.

The canyon is a meeting place between the Lower and Upper Sonoran Life Zones. This creates a great diversity of species in a small area. The endangered peregrine falcon (*Falco peregrinus anatum*) nests in the canyon and uses the riparian ecosystem as a hunting territory. The bald eagle (*Haliaeetus leucocephalus leucocephalus*) winters in the Park. It is not known if there is any nesting of this species in the canyon. Bell's vireo (*Vireo bellii*) nests in the main Zion Canyon. This bird is proposed for the endangered list. More investigation is needed on this species in the Park. The spotted owl (*Strix occidentalis lucida*) nests in the side canyons. This owl is listed by the state of Utah as limited.

Bird species are very common in the main canyon with 248 species recorded for the Park. Many utilize the riparian system for nesting and feeding activities. Gambel's quail (Lophortyx gambelii) were reestablished in the main canyon several years ago, but the present status of this species has not been studied.

The North Fork of the Virgin River is the main drainage through Zion Canyon. The river has wide seasonal fluctuations with high water during the spring run-off period and low flows during summer and fall. The river has an average gradient of 25 feet per mile. The average flow, based on 48 years of records, is 100 cfs. The extremes range from a high of 9,150 cfs recorded on December 6, 1966 to a low of 20 cfs recorded on July 31, 1963.

Species of fish found in the North Fork of the Virgin River are the speckled dace (Rhinichthys osculus), brown trout (Salmo trutta), mountain sucker (Pantosteus clarki) and Virgin River spinedace (Lepidomeda mollispinis mollispinis). The flannel mouth sucker (Catostomus latispinnis) has been found in the East Fork of the Virgin River within the Park but has not been found in the North Fork of the Virgin River. Brown trout are very scarce in Zion Canyon because of poor food supply, high summer water temperatures and poor spawning areas. The speckled dace and mountain sucker are relatively common in the main canyon. The Virgin River spinedace has been listed as threatened (Deacon 1979) and the state of Utah shows it as a declining species. Habitat alteration or destruction and competition are the main causes for the decline of this species through a good part of its range.

Invertebrates are not found in any quantity because of the scouring of the river during high run-off periods. Also, the sand carried by the river covers insect hiding places and reduces available habitat.

Associated with the springs in the canyon are mollusks not found elsewhere. The Zion snail (Petrophysa zionis) is a unique species found below the spring line on the sandstone cliffs in the upper portion of the canyon. This snail is endemic to Zion Canyon where its numbers and habitat are extremely limited. Birch Creek pond also contains a species of snail (Gyraulus parvus) which has not been found elsewhere in the Park. This snail is a relic of a 4,000 year old lake which once covered the floor of the upper canyon. This species survives on leakage from the Birch Creek spring development. Other springs in the canyon have not been investigated thoroughly enough to know what other unique or endemic species may be present.

The main canyon supports a diversity of fauna. The mule deer (Odocoileus hemionus) is the largest herbivore in the canyon, followed

in size by the desert bighorn sheep (Ovis canadensis nelsoni) which was recently reestablished in the Park. The beaver (Castor canadensis) is found in the Virgin River throughout the main canyon. The gray fox (Urocyon cinereoargenteus) and the ringtail cat (Bassariscus astutus) are common small mammals found in the canyon.

The archeological base map for Zion was used to locate known sites in the canyon to ascertain if any problems existed with the proposed alternatives. The known sites in the Park would not be directly affected by any of the alternatives. It is not known if any of the alternatives located outside the Park would affect known archeological sites. Many sites do exist just south of Springdale and effects would not be known until actual right-of-way was determined. The upper portion of the main canyon has not been covered by any extensive surveys. After a selection is made, it would be necessary to have a complete survey of the site. An evaluation and suggested mitigating measures study should be completed in order to comply with Executive Order 11593 and applicable National Park Service historic preservation policies.

The land to the south and west of Zion National Park is characterized by rugged dry slopes with deep erosional valleys. Although this area is not as deeply carved as Zion, it still has minimal access and most evidence of man is along the Virgin River. Most of the communities and the ranches and farms are situated on the valley floor created by the Virgin River. Rainfall is approximately 12 to 14 inches per year. Temperatures are variable with summer temperatures frequently exceeding 100 degrees and winter temperatures dropping into the 20s. Winters, however, are usually mild with the majority of the precipitation coming in the form of rain.

Vegetation is sparse and widely spaced to take advantage of available moisture. Trees are found only along the river or at the higher elevations. With the disruption of man, more exotic species are found along the rivers and roadways. The benches along the river are irrigated for stock feed or are grazed by livestock. The native plant species are similar to those in the Park. In some areas, plant species are becoming more rare and threatened.

Bird species are found throughout the area with most species common to the Lower Sonoran Life Zone present. Many of these birds are located in the riparian habitat along the main Virgin River.

The fish species in the Virgin River become slightly more numerous as the river becomes larger and bottom conditions change. However, irrigation run-off tends to increase the sediment load and the salt content becomes higher. The endangered Woundfin Minnow (Plagopterus

argentissimus) is found in the river below La Verkin Hot Springs. This hot springs seems to be an effective barrier to the upstream movement of most fish.

Mule deer (Odocoileus hemionus) are found throughout the area but not in large numbers. Available feed has kept the population from increasing. The increasing expansion by man has also kept the population low. Small mammals are common with species similar to those found in the Park.

ALTERNATIVES

Introduction

Public Law 91-383 (84 Stat. 827) authorizes the Secretary of the Interior, under such terms and conditions as he may deem advisable, to sell or lease to certain entities (persons, States or their legal subdivisions) services, resources or water within any area of the National Park System. To qualify for such sale or lease, the requesting entity must (1) provide "public accommodations or services within the immediate vicinity of an area of the National Park System to persons visiting the area"; and (2) demonstrate "that there are no reasonable alternatives by which to acquire or perform the necessary services, resources, or water." In Appendix F, National Park Service Special Directive 78-2 sets forth the criteria for implementing this law.

Additionally, Public Law 95-250 (92 Stat. 166) reaffirms the stewardship of the Secretary to protect, manage and administer areas of the National Park Service consistent with, and not in derogation of, the values and purposes for which these areas have been established.

The following alternatives have been identified to aid the National Park Service, representing the Secretary, as to (1) whether there are reasonable alternatives to the sale or lease of water from the Park to the town of Springdale; and (2) if providing water from the Park to the town, whether by sale, lease or otherwise, would be consistent with the Secretary's guardianship of the Park's values and purposes.

A dual irrigation-culinary system was considered. However, the town of Springdale is already using irrigation water for most of their lawn sprinkling and the cost of an irrigation system for the park residential areas would be extremely high. Therefore, the idea of a dual system has been dropped from consideration.

Under Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands), the Department of the Interior has a general mandate and broad responsibility for the management of the Nation's natural resources, including its streams, wetlands and floodplains.

The Departmental policy is to:

1. Exercise leadership and take action to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of wetlands and floodplains.

2. Avoid the direct or indirect support of wetland or floodplain development whenever there is a practicable alternative.

3. Reduce the risk of flood loss and minimize the impact of floods on human health, safety and welfare.

4. Restore and preserve the natural and beneficial values served by floodplains and wetlands.

5. Develop an integrated process to involve the public in the floodplain management decision making process.

6. Incorporate the Unified National Program for Floodplain Management into relevant Department programs.

In compliance with Section 6, B(1)(i) of the Floodplain Management and Wetland Protection Guidelines, flood hazard boundary maps were used to determine if the alternatives were in the floodplain. Some of the areas were not covered by flood hazard maps, and in these instances, it was assumed the project was in the floodplain. Appendix A contains the flood hazard maps that were available concerning the alternatives.

There are two birds on the endangered list and a third bird which is proposed for endangered listing found in the canyon. One endangered plant may be located in the main canyon. This cactus is of the correct genus and species, but it is not known if it is the endangered variety. Selection of Alternatives B or C would require Section 7 consultation with the United States Fish and Wildlife Service under Section 7 of the Endangered Species Act. With the endangered Woundfin Minnow (*Plagopterus argentissimus*) in the lower Virgin River, any development of water from the Virgin River would probably necessitate Section 7 consultation also. This would involve Alternatives D and E.

The park water system consists primarily of springs in the Birch Creek area and is piped to a one million gallon storage tank located near the mouth of Birch Creek. In 1979 the quantity of water flowing from these springs was 281 gpm. From the park storage tank, the water is piped to the residential areas in the Park, the Headquarters and Visitor Center and the two park campgrounds. Water in the amount of 60 gpm and usually greater quantities is piped to Springdale. At the present time, the combined needs of Springdale and in-Park uses equal the capacity of the spring system.

In addition to the water received from the Park, Springdale has two wells available for use. These wells produce water with moderately high quantities of dissolved material which makes them somewhat marginal for culinary use. See Appendix G for information on quality

and quantity. The town has at times mixed water from one of their wells with water from the Park to make more water available. One well has never been connected into the system. To maintain adequate storage, Springdale has a 500,000 gallon storage tank. To save water for culinary use, the town makes use of irrigation water for lawns and gardens.

The present park water system is located in the floodplain on the floor of a canyon that has historically experienced severe flooding and mud slides. Between Birch Creek, where the main park storage tank is located, and Park Headquarters, the main water line traverses one of the most unstable terrains in the Park--the Sentinel slide mass. This area has blocked the Virgin River several times in the past. The water line lies within easy reach of the river, which at this point has a gradient of about 100 feet per mile. The water line was broken in the 1960s by high water and was exposed again in the early 1970s but was not broken. This creates a highly erosive situation that could disrupt the water supply during peak use periods, usually early spring when run-off is highest.

Alternative AA

No Action

Selection of this alternative would maintain the present level of water usage and would cause no increase in water development within Zion National Park. Springdale receives 60 gpm from the park water system, and during heavy summer use periods, this amount has doubled.

This alternative would allow the Park to maintain present flows in the North Fork of the Virgin River and would not cause any further water removal from the canyon. The riparian ecosystem would remain essentially as it now exists: dependent on the seasonal flows of the river, the springs which flow into the canyon and the demands from upstream water users. No capital improvements or construction would occur under this alternative. The present facilities would be maintained and replaced as necessary.

Vegetation would remain relatively unchanged and the associated wildlife species would suffer no decrease in available water. The endangered species in the canyon would not be impacted. However, the present springs and their associated facilities would continue to be used and the water lost to the ecosystem. Pushing the present system to its capacity could alter the recharge rate of the aquifer unless adequate safeguards are taken. As has been done in the past, the Park and Springdale water users would be requested to curtail usage if the level in the Birch Creek storage tank begins to drop.

Springdale will experience minimum growth with the limited water supply available from the Park. To partially alleviate this problem, Springdale could activate one of their existing wells to increase their water supply by approximately 75 gpm. This would allow the town to approximately double their present water supply.

The portion of the water line between the Birch Creek tank and the Canyon Junction bridge is in the floodplain of the North Fork of the Virgin River and would remain susceptible to flood damage and mud slides. Human resources for operation and maintenance would remain at current levels. At present, operation and maintenance costs for the park system are about $18,000 per year. The Park would continue to supply 60 gpm to Springdale under the present agreement. Water from the existing system would continue to be committed to the needs of the Park and Springdale.

See details of costs in Appendix D.

Alternative A

Continue Present System with Additional Conservation Measures

This alternative would utilize existing springs currently in use to their maximum capacity. See Map A, Appendix E. To allow for peak use, an additional 500,000 gallon storage tank would be constructed in Springdale. The 60 gpm granted by law would still be delivered to Springdale from the Park and additional quantities could be made available if enough water exists in storage. A portion of the present main water line from Birch Creek to Park Headquarters would be replaced.

This alternative would require conservation measures for the Park and Springdale. For example, water saving devices could be installed to reduce culinary water consumption. Motels and residences could reduce use by using flow restrictors on showers and water saving devices on toilets. Water meters could be installed to pinpoint consumption. Water rates could be restructured to penalize excessive use. Such water conservation devices could result in a water savings of some 20 percent or approximately 12 gpm /17,280 gallons per day (gpd)/.

The town of Springdale has estimated that with anticipated growth it would require 330 gpm of water by 1990 and 443 gpm by 2019. Conservation measures identified in this alternative would increase the availability of water for Springdale's growth to an undetermined degree but would be less than the amounts mentioned above. The town is basing its need for future demands on 450 gpm (one cfs), which is the existing pending water right.

The alternative would require relatively little capital investment but would somewhat affect Springdale's growth if they restrict their water to park supplies. If Springdale connects one of their existing wells to the system, it would increase the town's water supply by approximately 75 gpm. This would allow Springdale to grow until they reach the capacity of their water supply again. However, the quality of water from the well could be such that it would require some mixing with the existing source, thus effectively reducing the well's output. Nevertheless, the total effect of both conservation efforts and the well would be an increase in the town water supply to a certain degree.

Animal and vegetative impacts are nearly the same as in the "No Action" alternative with the exception of the land loss because of the additional storage tanks. A second tank in Springdale would remove about .15 acre outside the Park. Pushing the present system to its capacity could cause problems during low water years because of aquifer recharge rates.

All new construction would be accomplished outside the floodplain in compliance with Executive Order 11988. Some of the existing pipeline is in the floodplain between Birch Creek storage tank and Park Headquarters. This line would be replaced as part of this proposed action because of age and possible leakage. The line would remain in the floodplain of the Virgin River and be susceptible to flood problems. All tanks, lines and related construction would be irretrievably committed if this alternative is selected.

Detailed costs are found in Appendix D.

Alternative B

Additional Spring Development

This alternative would involve the development of a spring located approximately 1,500 feet northwest of the Temple of Sinawava parking lot on the west side of the Virgin River. See Map B, Appendix E. An intake would be installed at the spring and a pipeline constructed to bring the water to the east side of the river. The pipeline would follow the present road alignment from the Temple of Sinawava parking lot to the existing one million gallon storage tank located at Birch Creek. An additional storage tank of the same size would be constructed in the Birch Creek area. From the Temple of Sinawava parking lot down to the Grotto Picnic Area would be new construction, as there has never been a water line in this area. It would be necessary to replace the water line from the Grotto down to the main storage tank with a larger diameter line than the one now in place. The entire system is intended to be a gravity flow operation.

The pipeline would require a river crossing east of the spring. Two additional river crossings may be required to maintain a gravity system near the river bend east of Angels Landing. The park road climbs a sandstone bluff south of Weeping Rock. This hill is 45 feet above the river. To maintain the gravity system, the pipeline would either have to follow the river or require a deep ditch to follow the road. Blasting through the sandstone bluff would be expensive and would severely impact the aesthetic and natural environment. To avoid this hill, two additional river crossings would be required.

The spring was measured at approximately 250 gpm in December of 1979. As that was a wet year, it should not be anticipated that the spring will flow at a rate of 250 gpm every year. Turbidity during seasonal high water presents additional treatment requirements.

In January and February of 1980, the spring discharged dirty water during periods of heavy rain raising questions about whether this source is a spring. It is possible that it is only a segment of the river that flows through seams in the sandstone walls parallel to the main river.

As an additional water source for this alternative, the town of Springdale would complete development of two existing wells in the town. These wells were drilled approximately two years ago and could supply an additional 150 gpm. Water from the wells contains dissolved material but when mixed with spring water from the Park, it would produce a usable product. It is anticipated that the existing Park Service commitment of 60 gpm for Springdale would be retained.

Pipeline construction would encroach upon the floodplain near the spring and east of Angels Landing (if it is determined that this is a desirable alternative to avoid the sandstone hill south of Weeping Rock). The new line from Birch Creek to Park Headquarters would still be located along the Virgin River and be susceptible to flood problems. All other proposed facilities will be located outside the floodplain.

Fish movement and spawning habits could be impacted by the placement of three river crossings within the relatively short distance from the spring to the Angels Landing crossing. Also, commitment of the entire spring flow for culinary purposes would destroy the existing plant and animal communities that exist in the spring and in the channel between the spring and the Virgin River. The threatened Virgin River spinedace is found in the spring and drainage channel. Anticipated low flow periods occur during the summer and early fall when both park and town demands are greatest. During maximum flow and reduced demand periods, some spring water could be allowed to flow from the spring into the river. This would not, however, prevent the destruction of in-stream invertebrates, vertebrates and aquatic plants.

Construction of the pipeline, storage tanks and other facilities would cause short-term disruption of the landscape and lower water quality in the Virgin River. Air pollution could result during the building phase. Care can be taken to minimize these impacts during construction. Once construction is complete, restoration of the landscape should be done to return the area to a natural appearance as soon as possible. Water quality deterioration would be short-term. Several endangered species are located in the valley and even short-term disruption could be an impact. A long-term impact will result with the construction of a second one million gallon storage reservoir near the present tank in Birch Creek. Approximately one acre will be irretrievably removed from the natural environment.

Detailed cost information is found in Appendix D.

Alternative C

River Treatment Plant Inside the Park for Both Springdale and the Park

This alternative would involve the construction of a 650 gpm water treatment plant to be located near Zion Lodge within the Park. See Map C, Appendix E. A structure to divert water from the Virgin River to the treatment plant would be located approximately 500 feet north of the Grotto Picnic Area. Water would gravity flow through a 10-inch line to the treatment plant. The treatment plant would require two backwash ponds which would also be located in the Lodge area. Treated water would be piped through a new 8-inch line to the existing one million gallon storage tank located at Birch Creek. An additional new 8-inch line would be constructed from Birch Creek to Park Headquarters. This would replace the existing 6-inch pipeline that follows the road alignment along the Virgin River.

Water records from the U.S. Geological Survey gauging station show a measured minimum flow of 20 cfs over the past seven years. This alternative would appropriate 7 percent of this minimum flow for domestic purposes. By appropriating river water for domestic use, all springs currently in use could be turned back into the river system. This would return a maximum of 281 gpm or 43 percent of the amount removed. Removal of 650 gpm during normal flow periods would show little evidence of impact because of seasonal variances already occurring in the flow. In periods of minimum flows, removal of 650 gpm could create environmental problems by raising water temperature and affecting fish spawning and migration habits.

The intake structure, treatment facility, backwash ponds and portions of the water lines would be located in the floodplain of the Virgin River. Thus, the main park water line would be vulnerable to flood hazards. Implementation of this alternative would require floodproofing all treatment facilities to comply with Executive Order 11988. Raising the building on piers or pilings would disrupt the gravity flow concept and require that the water be pumped into the treatment facility. The backwash ponds would have to be protected from flooding by construction of earthen embankments. The ponds cannot be relocated outside the floodplain, as the plain is very wide in this part of the canyon.

The treatment plant structure would be 50 feet by 50 feet by 12 feet high. Each of the two backwash ponds would be 50 feet by 50 feet by 6 feet deep. These ponds would require an additional 5,000 square feet of space for security fencing plus an additional commitment of land for support roads, flood protection and related facilities. The

total area required to house the facility would be approximately 15,000 square feet. This land would be irretrievably removed from the natural environment and could pose a conflict with a potential staging area for a possible future transportation system in the Park.

Sediment deposited in the backwash ponds would have to be removed periodically. This would require using heavy equipment to remove sediment. The sediment would then be hauled to the nearest sanitary landfill, which at the present time is 35 miles away.

Short-term disruption of vegetation and possible long-term disruption of soil could cause increased air pollution during construction. Care should be taken to reduce these problems to a minimum.

Detailed cost figures are found in Appendix D.

Alternative D

River Treatment Outside the Park for Springdale Only

This alternative would involve the construction of a 450 gpm water treatment plant in the community of Springdale, Utah. See Map D, Appendix E. The treatment plant would be located at the northern edge of Springdale near the southern park boundary. The proposed site is on the west side of the Virgin River above the 100 year floodplain. This alternative would be contingent on Springdale proving up on the water rights application.

All facilities would be owned and operated by the town. An intake structure would be placed adjacent to the Virgin River to remove water for the treatment plant. Water would be pumped through a 10-inch intake line from the river to an equalization pond and them pumped to the treatment plant. After treatment, the water would be pumped to the town's storage system. A 500,000 gallon storage tank would be needed in addition to the tank presently in use. Water rights would need to be purchased to acquire water from the river.

It is assumed that the plant would be about one-third smaller in size than the treatment plant discussed in Alternative C. This would mean a plant approximately 35 feet by 35 feet. The backwash ponds would be about 50 feet by 50 feet by 6 feet deep. The equalization pond would be approximately 110 feet by 110 feet by 6 feet deep. The plant and the attendant facilities would require about two acres. This size is an estimate, as figures are presently unavailable.

It is also assumed that the Park would continue to supply 60 gpm to the town as in the past. During the winter, it may be possible for the town to shut down the treatment plant and use the water from the Park to lower operating costs. However, it may be more costly to allow the plant to set idle for the winter months, and it would be difficult to find plant operators who would be available to work only part of the year.

Impacts for this alternative would be similar to those mentioned in Alternative C. The treatment plant and associated structures would be located on previously disturbed land and should require minimal archeological examination. The facility would need to be fenced because of the hazards from the open backwash ponds and the equalization pond. The location would be highly visible from Utah Highway 9 leading to Zion National Park and would require some landscaping to screen the area from the road. The site would avoid the floodplain except for the river intake structure. Removal of 450 gpm from the river would probably show little evidence of impact because of the

wide fluctuations in the Virgin River's flows. However, during the summer low flow periods, removal of one cfs could create a detrimental effect on aquatic species by affecting spawning and disrupting normal flow patterns. The socioeconomic impact on Springdale could be a problem because of the high cost of constructing and maintaining a water treatment plant.

Detailed cost information is found in Appendix D.

Alternative E

River Treatment Plant Outside the Park for NPS and Springdale

This alternative would construct a 650 gpm water treatment plant in the town of Springdale supplying both the Park and the town. See Alternative D and Maps D and E, Appendix E. The plant size would be similar to the plant discussed in Alternative C. Water rights would need to be acquired to acquire water from the river. Springdale would need to build an additional 500,000 gallon storage tank and the Park would build a one million gallon storage tank in the Oak Creek area inside the Park. Water would be taken from the Virgin River through an intake structure and pumped into an equalization pond. Water would be taken from the equalization pond and treated in the facility. After treatment, the water would be pumped to both storage systems.

It is assumed that the 60 gpm that has been delivered to Springdale from the Park water system would cease. The attendant ponds and facilities for this alternative would be approximately the same as for Alternative C. The water line currently in use to supply the town from the Park water system would be used to transport water from the treatment facility to the Park.

Impacts for this alternative would be approximately the same as for Alternative D with the addition of the land loss for the one million gallon tank in Oak Creek inside the Park. The present Park Birch Creek system in the Park could be returned to the environment. Two full-time plant operators would be needed for a plant of this size. Short-term disturbance of vegetation would occur where the water lines were laid, but this could be taken care of by reseeding. Socioeconomic impact would be lessened for Springdale with the Park participation in the project. The same consideration for archeological examination applies to this alternative as in Alternative D.

A breakdown of costs is found in Appendix D.

Alternative F

Well Supply from Hurricane for NPS and Springdale

This alternative would involve the drilling and development of a well in the Dixie Springs area west of the community of Hurricane, Utah, approximately 25 miles southwest of Zion National Park. See Map F, Appendix E. There is reportedly an adequate recharge and underground reservoir area to support additional wells. The water is of good quality and would require minimal treatment for culinary purposes. The water would be pumped from the well in an 8-inch pressure line following the present road alignment on Utah Highway 9 from Dixie Springs to Springdale.

The pipeline would pass through the town of Hurricane along the right-of-way on Highway 9. Between the towns of Hurricane and La Verkin, it would cross the Virgin River on the existing highway bridge. From La Verkin, the line would gain elevation rapidly. Soil type would change from sandy with loose rock to more dense concentrations of solid sandstone. Once the line reached the bench above La Verkin, soil type again would become underlaid with sandstone and the route of the pipeline would become confined between the Virgin River and the sandstone cliffs to the north. There would be a booster pumping station in the vicinity of the town of Virgin, Utah, to maintain water pressure.

Springdale would need to construct an additional 500,000 gallon tank adjacent to their existing storage tank. The Park would build a one million gallon storage tank in the Oak Creek area inside the Park. It is assumed that under this alternative, the Park would no longer supply Springdale the 60 gpm that has been delivered in the past. Water rights would have to be acquired from the town of Hurricane to acquire water in the Dixie Springs area.

The water line would pass through the small communities of Virgin and Rockville, which could allow these towns to purchase water from the system. This could help reduce the costs to Springdale and the Park if adequate agreement could be reached with these communities.

Impacts would be generally short-term for this project with the exception of the land committed to the well, storage tanks and pump station. Construction at the well site would disrupt vegetation for a time. The water line would follow the existing road alignment, thereby being located in a previously disturbed area. The line from the town of Virgin to Springdale would at times be in the floodplain of the Virgin River. The necessary safety measures should be taken to comply with Executive Order 11988. There are some known archeological

sites near the proposed pipeline route east of Rockville. Other sites possibly exist at other places along the line. The entire route should be examined by an archeologist to determine the location and significance of all archeological sites. Construction of the storage tanks would take place on previously disturbed land. There would be some loss of trees and vegetation because of building, but this should be confined to the immediate area of construction.

Detailed cost information is found in Appendix D.

Alternative G

Well Supply From the Plains for NPS and Springdale

This alternative would drill and develop two wells to be located in the "Plains" area of Washington County approximately 10 miles south and west of Springdale. See Map G, Appendix E. An 8-inch line would come down the old road that crosses from Rockville to Utah Highway 59. Water rights would need to be acquired in the Plains area. This alternative would include construction of a 500,000 gallon storage tank in Springdale next to their present tank and a one million gallon storage tank in the Oak Creek area inside the Park. It has not been determined if the Park would move its present one million gallon tank to the Oak Creek site or build a new one. The project would include the installation of a hydrogenerator system to provide power to pump the wells. It would be a gravity system once the water has been pumped from the wells. Under this alternative, it is assumed that the Park would no longer supply Springdale 60 gpm as in the past.

Impacts would be the land loss at the well development sites and for the storage tanks. Short-term disruption of vegetation would occur at the well site and along the pipeline route. However, since the pipeline would follow the road alignment and be in a previously disturbed area, revegetation should not be a problem. There would be a river crossing just east of Rockville which would be in the flood-plain of the Virgin River. Construction of this crossing should comply with the requirements of Executive Order 11988. The river would have periods of murky water during construction, but if care is taken, this impact should be confined to the period of actual construction.

A geologist's report on the Plains area stated the recharge area is relatively small and the precipitation low. He further stated that during dry years, wells in this area could drop in production. (See Hydrogeologic Report, "Groundwater Alternatives for Springdale," in Appendix C.)

Detailed information on costs can be found in Appendix D.

Alternative H

Well Supply From the Plains for Springdale Only

This alternative is basically the same as Alternative G with the following exceptions. See Map H, Appendix E. The Park Service would not participate in this alternative. Accordingly, there would be only one well drilled and developed and the water line would be reduced to a 6-inch diameter. Springdale would have to acquire water rights in the Plains area. The town of Springdale would construct a 500,000 gallon storage tank east of Rockville on the south side of the Virgin River. It is assumed that the Park would continue to supply 60 gpm to the town of Springdale.

Impacts would be similar to Alternative G with the exception that there would be no storage tank construction inside the Park. Socio-economic impacts would be slightly increased for Springdale without Park participation.

Detailed cost figures are found in Appendix D.

Alternative I

Well Supply From Shunesburg for NPS and Town

A geological examination of the confluence of the East Fork of the Virgin River and South Creek revealed an alluvial deposit with potential as a source for a dependable well. See Map I, Appendix E. The site is on private property and water rights would have to be obtained. Arrangements would be formalized with the landowner prior to beginning any actual work.

For this alternative, a well and pump station would be developed near the East Fork of the Virgin River. The water would then be pumped through an 8-inch pressure line to a storage reservoir to be built east of Rockville for use by the town of Springdale. From the new reservoir, an 8-inch gravity flow line would be constructed through Springdale to connect with the existing 6-inch line at the park boundary. A one million gallon tank would be constructed in the Oak Creek area within the Park. A chlorinator building would be built near the well site. Chlorination is anticipated to be the only treatment required. Line construction from the reservoir would require one and possibly two river crossings depending on how far west the reservoir would have to be located in order to achieve sufficient elevation for adequate flow throughout the system.

By pumping from an underground source, the impact on Virgin River flows would be eliminated. In addition, the Birch Creek springs presently being used for domestic purposes could be turned back into the Virgin River. This would enhance both volume and clarity of the river.

The pipeline would cross previously untouched hillsides adjacent to the Virgin River. Care would have to be exercised to assure that the line did not compromise the aesthetic value of the area. River crossings would have to be made in such a way as to minimize the impact on fish movement and spawning. Some short-term disruption would be unavoidable during construction, but mitigation could be accomplished through revegetation along the pipeline route. River crossings would also cause periods of murky water in the Virgin River.

Approximately one acre of natural habitat would be irreversibly committed to construction of the storage reservoir, chlorinator building, and the well and pump house. Access to the well and chlorinator would be over an existing dirt road.

Intrusion into the floodplain would occur only at the well site and at the river crossings. The chlorinator house could be located near the well but on higher ground to avoid possible flood damage.

Any construction activities would cause some short-term disruption of the environment along the pipeline route and at the site of the well, chlorinator and reservoir. Throughout the useful life of the system, however, only minimal disruption should take place in the form of maintenance and repair of the system. Construction of river crossings would also cause brief periods of murky water in the Virgin River. Care in the selection of crossing sites and construction methods would confine this impact to the period of actual construction.

Detailed cost information is found in Appendix D.

Alternative J

Well at Shunesburg for Springdale Only

This alternative is basically the same as Alternative I except there would be no Park Service participation. See Map I, Appendix E. The well and accompanying lines and structures would be as in Alternative I.

Impacts would be the same as for Alternative I with the exception that there would be no storage tank in Oak Creek inside the Park. Socio-economic impacts for Springdale would be slightly increased without Park participation.

Detailed cost information is found in Appendix D.

SUMMARY OF ALTERNATIVES

In order to assess the long-term water situation for Zion National Park and the town of Springdale, Utah, a total of 11 alternatives are being considered. Numerous aspects of each alternative were identified, researched, evaluated and compared in order to determine the most reasonable and acceptable alternative. In alternatives in which the National Park Service and the town of Springdale cooperate in the project, costs would be based on the estimated proportionate use of water. These costs would be divided on a 30 percent NPS share/70 percent Springdale share basis.

All of these alternatives are contingent on the following assumptions:

1. Water rights are available for each alternative water source.

2. Grants and loans to the town will be forthcoming.

3. In alternatives involving Park participation, construction funds can be obtained in sequence with the orderly development of the selected plan.

The accompanying chart rates the alternatives on a variety of topics. Please see the individual alternatives for detailed information. Cost information is found in Appendix D.

SUMMARY OF ALTERNATIVES

	Alt. AA	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E	Alt. F	Alt. G	Alt. H	Alt. I	Alt. J
Endangered Species	2	2	3	3	2	2	2	2	2	2	2
Wildlife and Vegetation	2	2	4	3	3	3	2	2	2	2	2
Wetlands and Floodplains	4	4	4	4	3	3	3	2	2	3	3
Cultural Resources	1	1	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]	5[a]
Socioeconomic	3	3	3	1	1	1	1	1	1	1	1
Aesthetics	2	2	4	4	2	2	2	2	2	2	2
Cost	2	2	4	4	4	4	4	3	3	3	3

Legend:

1 - No cost or impact
2 - Low cost or impact
3 - Moderate cost or impact
4 - High cost or impact
5 - Insufficient data to make valid rating
a - Archeological survey needed prior to ground disturbance

LIST OF PREPARERS

Clay Alderson, Superintendent, Cedar Breaks National Monument

Larry L. Hays, Resource Management Specialist, Zion National Park

Robert B. Kasparek, Environmental Protection Specialist, Rocky Mountain Region

CONSULTATION AND COORDINATION WITH OTHERS

This assessment of alternatives was prepared after consultation with the staff of Zion National Park, staff individuals in the Rocky Mountain Regional Office, Creamer & Noble, engineers for the town of Springdale, and some of the city council members of Springdale.

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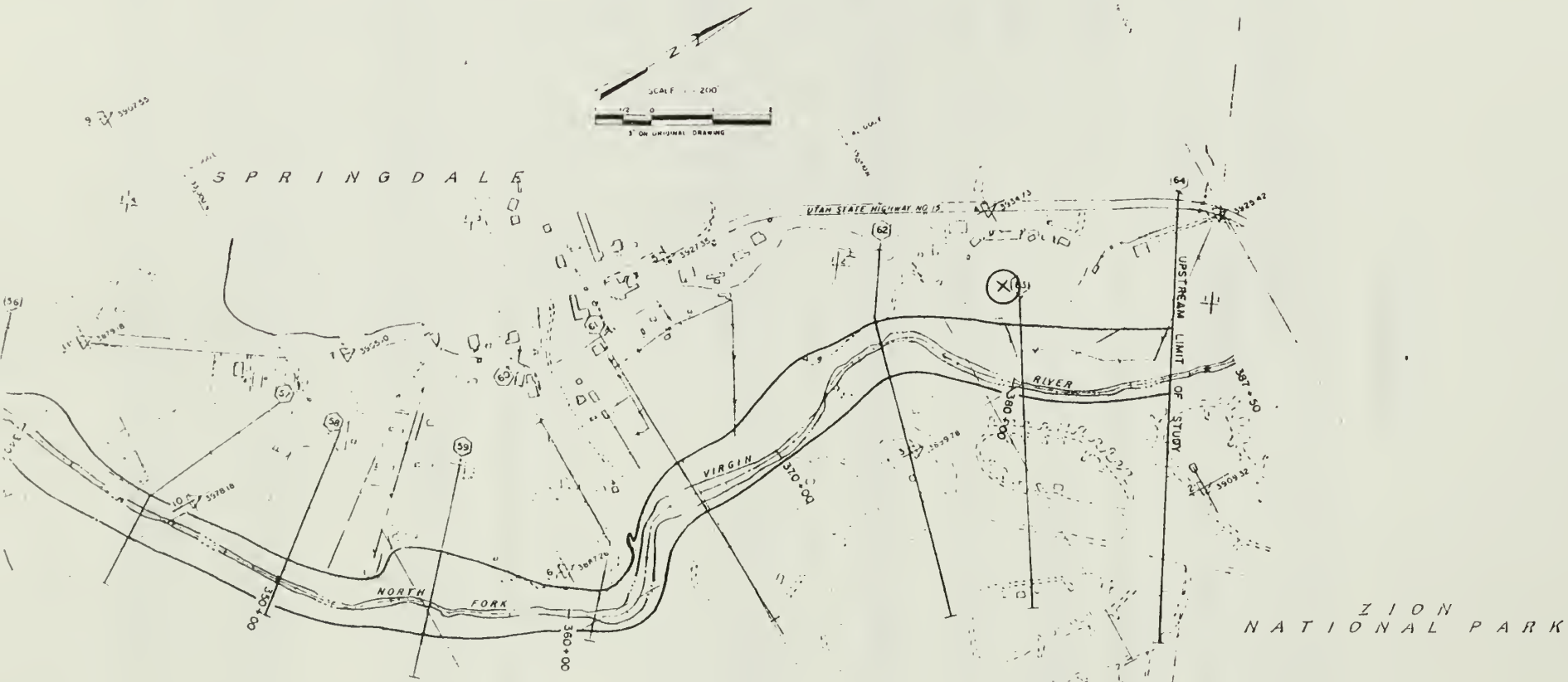
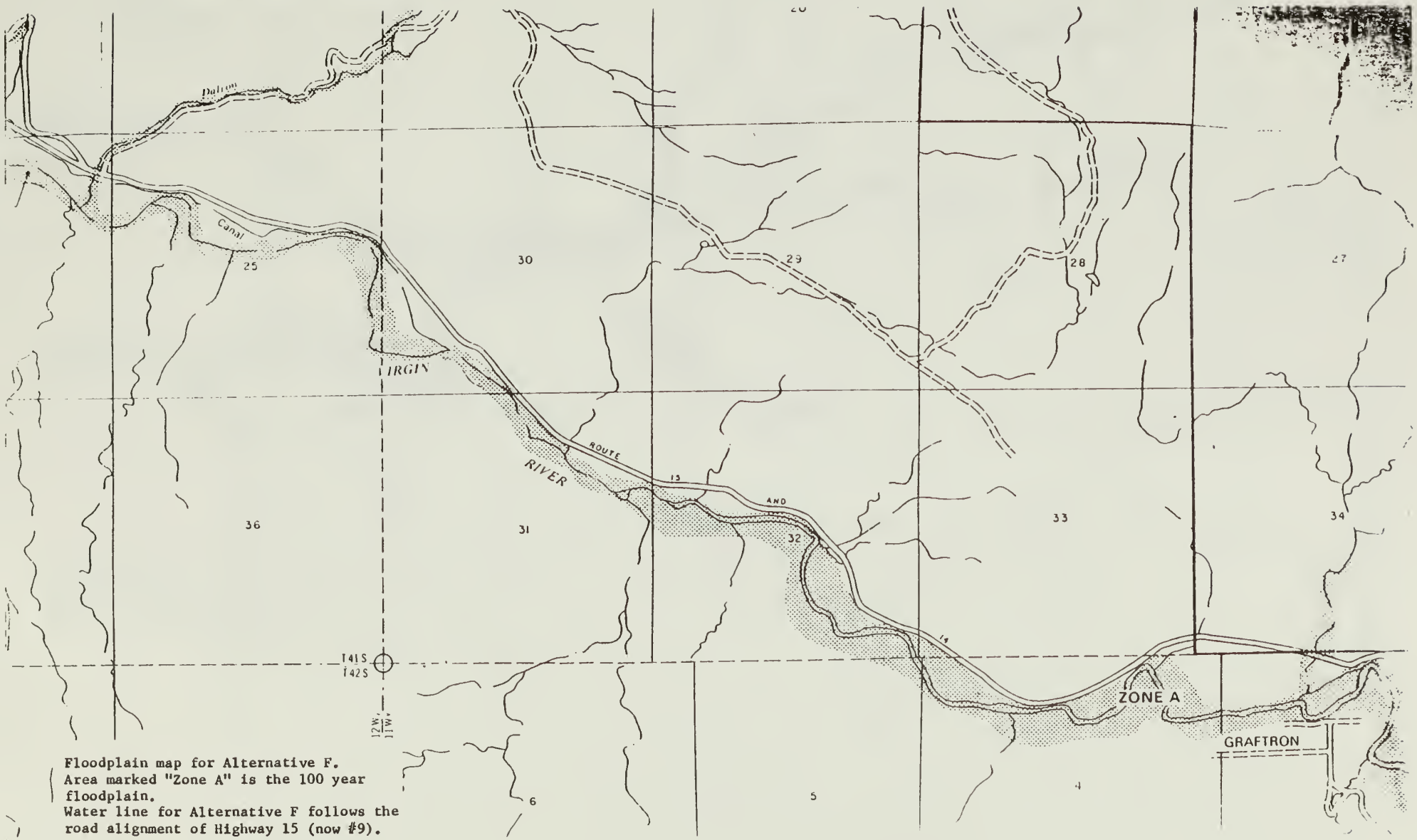
APPENDIX A

FLOODPLAIN MAPS

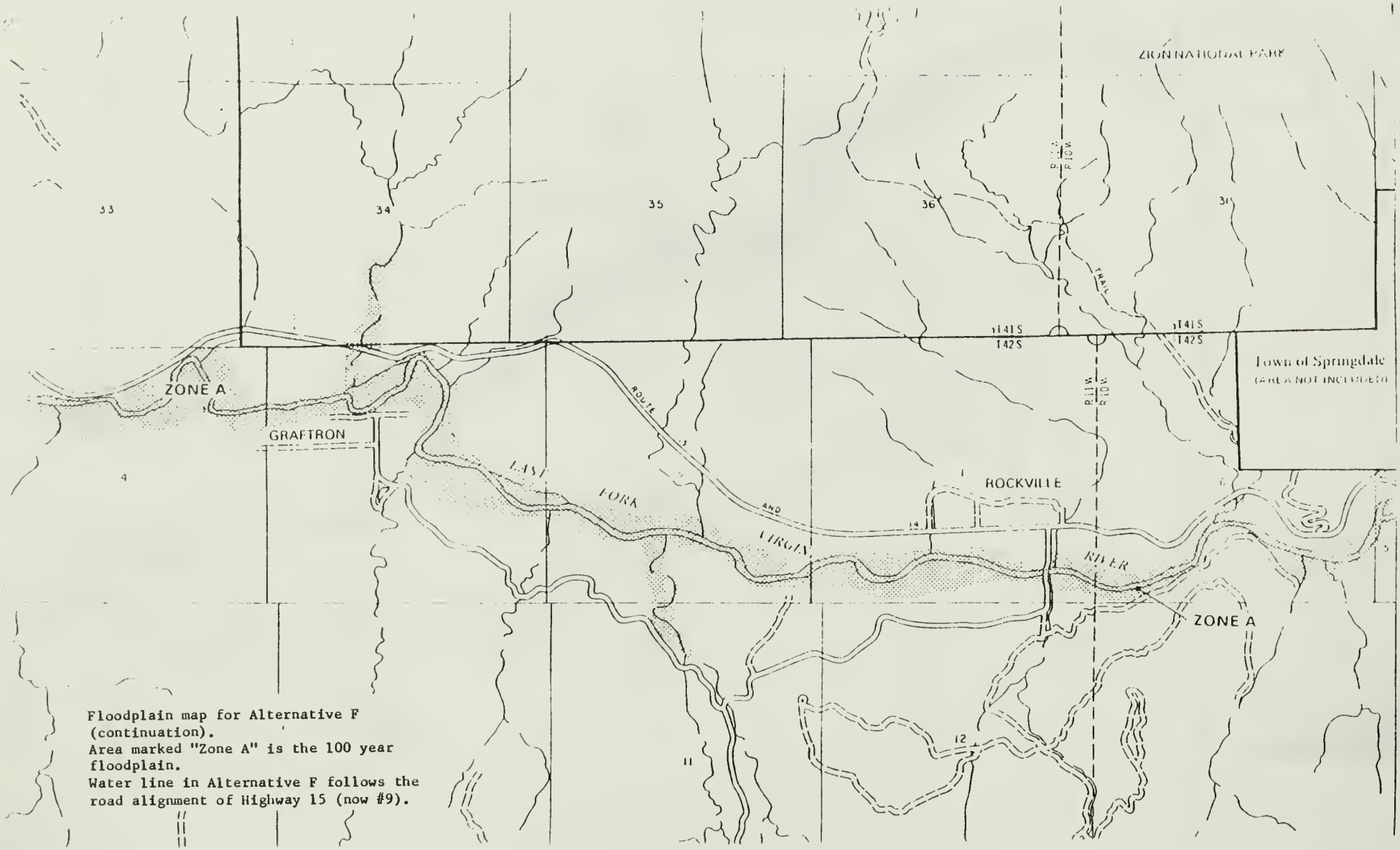


Floodplain map for Alternatives D & E.
Gray area is the 100 year floodplain.

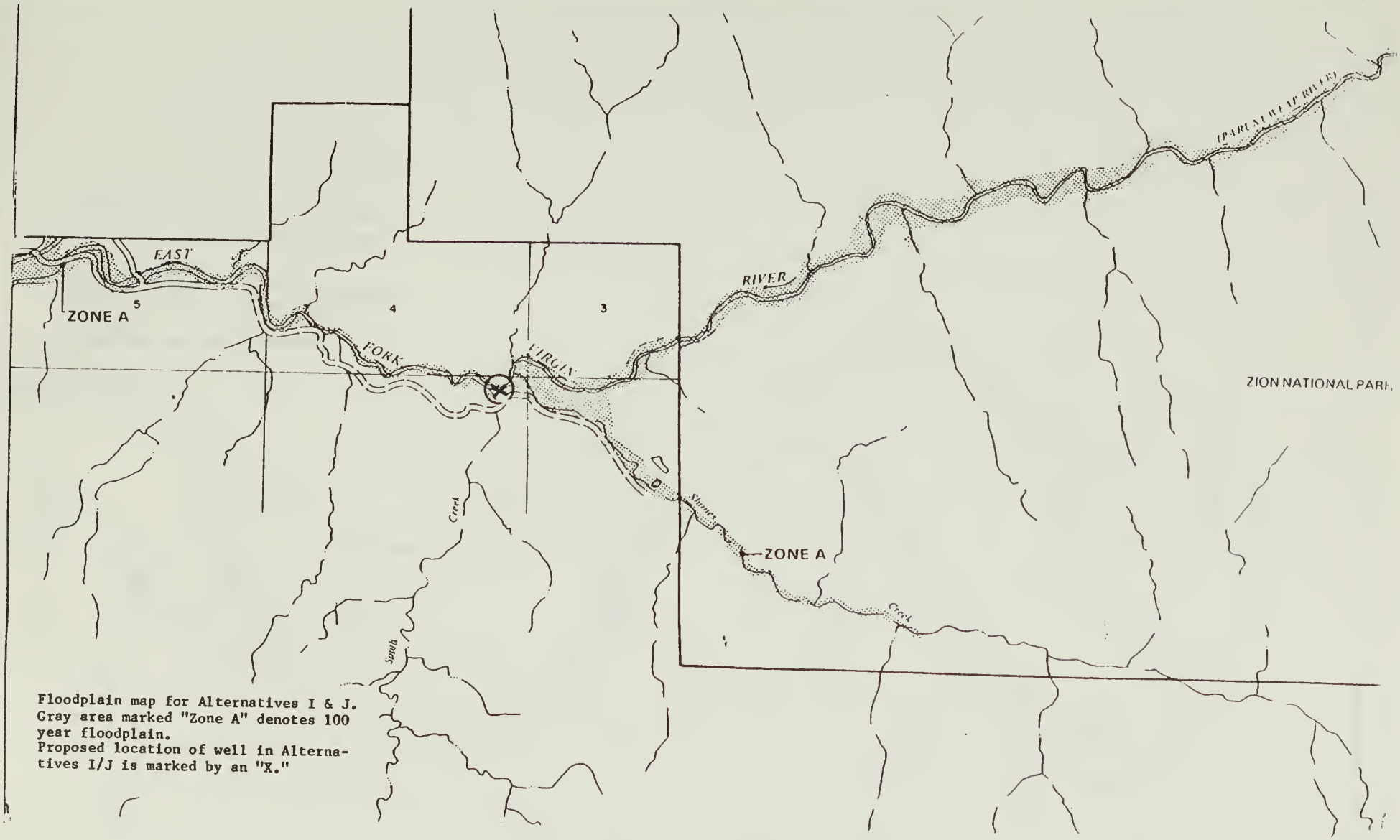
Approximate location of proposed alternative is marked with an "X."



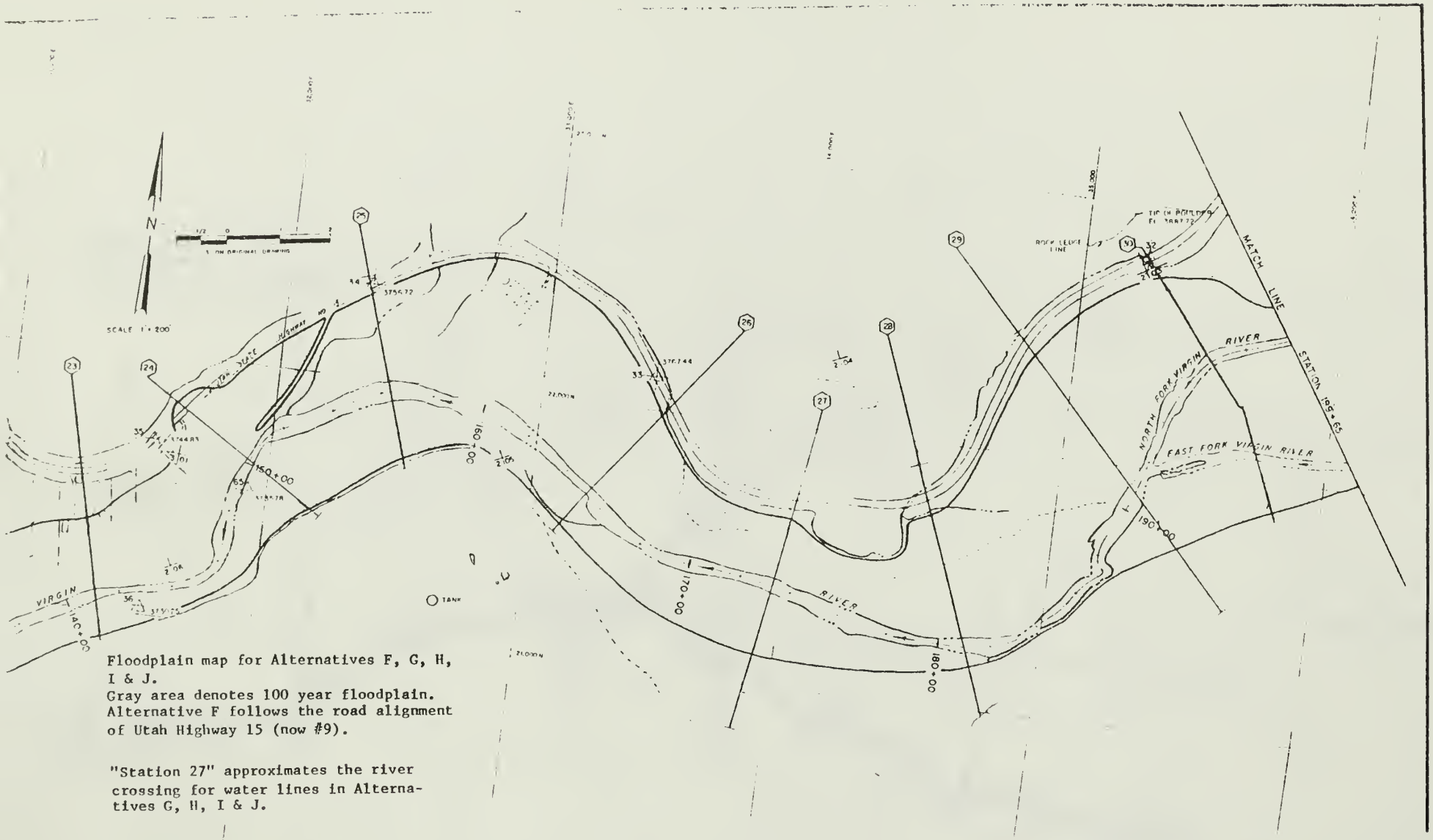
Floodplain map for Alternative F.
Area marked "Zone A" is the 100 year floodplain.
Water line for Alternative F follows the road alignment of Highway 15 (now #9).



Floodplain map for Alternative F (continuation).
Area marked "Zone A" is the 100 year floodplain.
Water line in Alternative F follows the road alignment of Highway 15 (now #9).



Floodplain map for Alternatives I & J. Gray area marked "Zone A" denotes 100 year floodplain.
Proposed location of well in Alternatives I/J is marked by an "X."



Floodplain map for Alternatives F, G, H, I & J.
Gray area denotes 100 year floodplain.
Alternative F follows the road alignment of Utah Highway 15 (now #9).

"Station 27" approximates the river crossing for water lines in Alternatives G, H, I & J.

APPENDIX B

VIRGIN RIVER WATER RECORDS

DEC 23 1977

09405500 North Fork Virgin River near Springdale, Utah

LOCATION.--Lat 37°12'35", long 112°58'40", in SW¼NW¼ sec.22, T.41 S., R.10 W., Washington County, on right bank, 0.1 mile (0.3 km) downstream from point of diversion of Springdale Canal, 0.5 mile (0.8 km) downstream from [illegible] (3.1 km) northeast of Springdale.

DRAINAGE AREA.--350 sq mi (906 km²), approximately.

PERIOD OF RECORD.--May 1913 to June 1914, June to November 1923, April to June, August and September 1925 (fragmentary), October 1925 to current year. Published as Zion Creek near Springdale 1913-14 (flow of Springdale Canal not included) and as Potuchuweap River near Springdale 1923, 1925-32.

GAGE.--Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 23, 1913 to June 30, 1914, nonrecording gage at site 3.2 miles (5.1 km) downstream at different datum. June 6, 1923 to Dec. 18, 1949, nonrecording gages at several sites within 0.8 mile (1.3 km) of present site at various datums.

AVERAGE DISCHARGE.--48 years, 100 ft³/s (2.832 m³/s), 72,450 acre-ft/yr (89.3 hm³/yr).

EXTREMES.--Current year: Maximum discharge, 1,970 ft³/s (55.8 m³/s) May 10 (gage height, 5.72 ft or 1.743 m); minimum, 28 ft³/s (0.79 m³/s) Dec. 6.

Period of record: Maximum discharge, 9,150 ft³/s (259 m³/s) Dec. 6, 1966, from rating curve extended above 2,000 ft³/s (56.6 m³/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.25 ft (3.124 m); minimum observed, 20 ft³/s (0.57 m³/s) July 31, 1963.

REMARKS.--Records good. Figures given herein include Springdale Canal, which diverts water in NW¼NW¼ sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	65	60	51	65	54	90	92	668	687	107	54	67
2	65	60	60	65	58	89	88	673	578	99	53	67
3	66	53	49	67	57	79	76	689	546	92	53	67
4	135	52	68	52	54	88	74	795	563	88	53	67
5	87	53	54	49	56	99	76	793	450	86	61	67
6	60	52	38	49	63	77	110	642	413	85	56	68
7	62	50	46	45	70	99	136	805	390	84	53	67
8	53	42	49	46	71	80	103	896	361	80	52	65
9	59	45	46	50	67	79	110	1,110	338	77	50	64
10	60	45	42	52	66	78	150	1,270	312	75	50	66
11	53	44	43	54	73	89	180	1,270	284	69	49	67
12	51	49	44	52	77	123	270	1,190	260	58	51	67
13	51	49	48	52	74	92	350	1,080	243	76	53	68
14	52	48	45	52	67	97	365	1,110	428	71	54	68
15	115	50	41	54	69	86	300	1,140	282	65	60	67
16	75	59	44	57	67	84	280	1,070	235	70	64	65
17	60	119	50	63	66	86	320	1,090	214	69	105	64
18	83	59	50	58	66	93	300	1,170	196	63	120	66
19	211	54	51	48	52	84	262	1,220	179	73	93	65
20	208	58	51	48	65	90	229	1,160	168	67	74	65
21	150	47	54	45	71	93	210	954	159	64	238	55
22	111	52	52	54	72	100	227	877	150	64	120	48
23	88	49	52	50	74	98	319	856	148	60	72	46
24	73	48	50	52	77	90	426	815	142	57	68	47
25	65	50	50	55	80	89	556	762	136	56	66	48
26	58	54	49	57	81	94	605	909	128	55	66	49
27	58	54	49	53	82	98	639	716	123	54	64	49
28	56	47	56	52	122	126	651	684	121	57	64	50
29	95	44	53	54	------	98	655	675	114	65	65	49
30	95	49	45	57	------	91	662	642	112	58	65	49
31	76	------	44	54	------	88	------	631	------	55	65	------
TOTAL	2,536	1,604	1,532	1,619	1,957	2,851	8,857	28,358	8,418	2,203	2,247	1,817
MEAN	81.8	53.5	49.4	52.2	69.9	92.0	295	915	281	71.1	72.5	60.6
MAX	211	119	88	63	122	126	662	1,270	607	107	238	68
MIN	45	42	38	45	54	77	74	631	112	54	44	46
AC-FT	5,030	3,180	3,040	3,210	3,880	5,650	17,570	56,250	16,700	4,370	4,460	3,600

CAL YR 1972 TOTAL 24,660 MEAN 67.4 MAX 631 MIN 33 AC-FT 48,910
WTR YR 1973 TOTAL 63,999 MEAN 175 MAX 1,270 MIN 38 AC-FT 126,900

PEAK DISCHARGE (BASE, 800 CFS).--MAY 10 (2130) 1,970 cfs (5.72 ft).

NOTE.--No gage-height record July 15 to Aug. 23.

DEC 28 1977

09405500 North Fork Virgin River near Springdale, Utah

LOCATION.—Lat 37°12'35", long 112°58'40", in SW¼NW¼ sec.22, T.41 S., R.10 W., Washington County, on right bank in Zion National Park, 0.2 mile (0.3 km) downstream from point of diversion of Springdale Canal, 0.5 mile (0.8 km) downstream from Pine Creek, and 1.9 miles (3.1 km) northeast of Springdale.

DRAINAGE AREA.—350 mi² (906 km²), approximately.

PERIOD OF RECORD.—May 1913 to June 1914, June to November 1923, April to June, August and September 1925 (fragmentary), October 1925 to current year. Published as Zion Creek near Springdale 1913-14 (flow of Springdale Canal not included) and as Mukuntuweap River near Springdale 1923, 1925-32.

GAGE.—Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 13, 1913 to June 30, 1914, nonrecording gage at site 3.2 miles (5.1 km) downstream at different datum. June 6, 1923 to Dec. 14, 1969, nonrecording gages at several sites within 0.8 mile (1.3 km) of present site at various datums.

AVERAGE DISCHARGE.—49 years, 99.5 ft³/s (2.818 m³/s), 72,090 acre-ft/yr (88.9 hm³/yr).

EXTREMES.—Current year: Maximum discharge, 776 ft³/s (22.0 m³/s) Sept. 5 (gage height, 3.48 ft or 1.061 m); minimum, 24 ft³/s (0.68 m³/s) July 27.

Period of record: Maximum discharge, 9,150 ft³/s (259 m³/s) Dec. 6, 1966, from rating curve extended above 2,000 ft³/s (56.6 m³/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.25 ft (3.124 m); minimum observed, 20 ft³/s (0.57 m³/s) July 31, 1963.

REMARKS.—Records good. Figures given herein include Springdale Canal, which diverts water in NW¼NW¼ sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	49	62	56	50	49	54	75	110	55	49	49	43
2	49	62	63	45	48	96	151	115	62	48	31	43
3	49	62	47	43	47	85	75	129	63	46	39	43
4	49	62	53	45	46	54	71	127	61	45	29	43
5	50	62	52	53	49	55	76	118	60	48	27	91
6	50	58	52	49	43	60	75	112	58	47	31	67
7	50	60	53	55	43	59	80	105	58	47	25	36
8	50	60	54	63	42	60	74	114	56	47	27	34
9	51	59	51	61	42	59	77	115	55	46	31	32
10	51	60	51	51	45	59	76	110	55	46	30	32
11	53	59	52	47	48	57	75	102	55	46	31	41
12	54	58	55	52	48	63	76	90	55	44	36	42
13	53	57	54	57	51	65	69	85	55	44	43	42
14	52	57	54	53	51	72	68	75	57	43	43	41
15	52	55	49	49	48	80	68	72	52	45	43	45
16	52	55	52	50	49	84	74	72	51	42	42	44
17	53	54	54	56	51	88	86	69	51	44	41	43
18	54	90	54	61	48	87	101	63	55	46	40	48
19	53	65	48	54	49	84	98	59	55	73	42	46
20	54	55	49	55	46	78	81	59	56	56	44	35
21	55	61	49	102	41	72	84	61	54	78	43	33
22	57	61	59	51	46	72	89	60	53	69	41	32
23	58	62	55	46	49	71	104	59	52	36	39	35
24	58	55	51	46	46	71	113	57	51	29	39	37
25	58	60	46	45	47	75	106	51	49	27	40	37
26	65	58	50	45	52	81	112	55	49	25	41	35
27	64	50	46	45	53	76	97	52	47	24	41	35
28	65	52	68	45	52	71	96	49	46	29	43	36
29	64	59	56	46	------	71	89	48	47	35	43	35
30	61	57	54	45	------	87	93	47	46	36	43	38
31	60	------	45	46	------	84	------	47	------	38	43	------
TOTAL	1,693	1,787	1,624	1,611	1,329	2,230	2,609	2,491	1,619	1,378	1,179	1,247
MEAN	54.6	59.6	52.4	52.0	47.5	71.9	87.0	80.4	54.0	44.5	38.0	41.6
MAX	65	90	63	102	53	96	151	128	63	78	49	91
MIN	49	50	45	43	41	54	68	47	46	24	25	32
AC-FT	3,360	3,540	3,220	3,200	2,640	4,420	5,170	4,940	3,210	2,730	2,340	2,470

CAL YR 1973 TOTAL 63,431 MEAN 174 MAX 1,270 MIN 45 AC-FT 125,800
WTR YR 1974 TOTAL 20,797 MEAN 57.0 MAX 151 MIN 24 AC-FT 41,250

PEAK DISCHARGE (BASE, 800 CFS).--No peak above base.

09405500 North Fork Virgin River near Springdale, Utah

LOCATION.—Lat 37°12'35", long 112°58'40", in SW¼NW¼ sec.22, T.41 S., R.10 W., Washington County, on right bank in Zion National Park, 0.2 mile (0.3 km) downstream from point of diversion of Springdale Canal, 0.5 mile (0.8 km) downstream from Pine Creek, and 1.9 miles (3.1 km) northeast of Springdale.

DRAINAGE AREA.--350 mi² (906 km²), approximately.

PERIOD OF RECORD.—May 1913 to June 1914, June to November 1923, April to June, August and September 1925 (fragmentary), October 1925 to current year. Published as Zion Creek near Springdale 1913-14 (flow of Springdale Canal not included) and as Mukuntuweap River near Springdale 1923, 1925-32.

GAGE.—Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 13, 1913 to June 30, 1914, nonrecording gage at site 3.2 miles (5.1 km) downstream at different datum. June 6, 1923 to Dec. 14, 1949, nonrecording gages at several sites within 0.8 mile (1.3 km) of present site at various datums.

AVERAGE DISCHARGE.—50 years, 99.2 ft³/s (2.809 m³/s), 71,870 acre-ft/yr (88.6 hm³/yr).

EXTREMES.—Current year: Maximum discharge, 4,140 ft³/s (117 m³/s) July 29 (gage height, 8.95 ft or 2.728 m from highwater mark); minimum, 30 ft³/s (0.85 m³/s) several days in September.

Period of record: Maximum discharge, 9,150 ft³/s (259 m³/s) Dec. 6, 1966, from rating curve extended above 2,000 ft³/s (56.6 m³/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.23 ft (3.124 m); minimum observed, 20 ft³/s (0.57 m³/s) July 31, 1963.

REMARKS.—Records good, except those for period of no gage-height record. Figures given herein include Springdale Canal, which diverts water in SW¼NW¼ sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	37	60	37	43	56	78	43	137	277	69	83	64
2	36	63	36	51	48	87	58	178	257	64	80	61
3	33	40	36	48	47	71	55	175	247	66	77	59
4	33	40	47	46	52	61	62	202	225	69	76	55
5	33	43	52	43	54	72	69	125	206	69	78	53
6	32	48	41	40	52	119	82	49	186	67	75	53
7	36	39	37	41	52	76	58	92	182	64	70	54
8	35	43	34	44	52	71	57	111	163	62	67	55
9	34	41	32	46	54	69	59	187	157	62	64	75
10	35	39	32	48	55	81	58	238	145	60	61	69
11	34	39	38	46	53	69	57	271	137	56	60	62
12	34	40	41	46	52	59	59	279	133	58	60	61
13	36	38	45	41	52	55	59	284	127	53	59	44
14	36	60	36	40	53	62	67	323	125	52	59	47
15	38	46	33	41	71	53	62	336	123	56	63	44
16	36	44	36	43	63	62	62	331	114	60	63	39
17	36	42	43	46	65	58	67	283	247	62	62	37
18	35	43	43	45	62	57	62	271	106	58	61	35
19	34	38	40	44	61	62	63	314	106	52	62	33
20	34	42	37	44	59	69	70	398	102	45	90	33
21	37	43	35	45	59	71	84	278	92	41	92	32
22	36	46	35	43	60	82	187	227	86	41	78	38
23	37	47	35	43	58	59	114	224	82	49	74	38
24	32	62	39	45	57	68	116	235	78	66	70	39
25	33	43	37	47	56	79	159	276	71	68	68	38
26	32	46	37	50	59	82	122	302	74	68	78	35
27	80	41	39	52	64	49	104	308	78	87	65	44
28	679	37	33	50	76	45	98	258	77	68	59	45
29	619	35	43	56	---	58	105	252	83	884	62	44
30	220	35	44	53	---	61	114	244	78	120	62	45
31	100	---	43	51	---	67	---	284	---	97	63	---
TOTAL	2684	1251	1196	1411	1588	2096	2367	7464	4926	2771	2133	1358
MEAN	86.6	41.7	38.6	45.5	56.7	67.6	78.9	241	134	89.4	68.8	46.6
MAX	879	60	52	54	71	119	139	398	277	884	92	75
MIN	32	35	32	40	47	45	58	92	71	41	59	38
AC-FT	5170	2480	2370	2800	3150	4160	4690	14800	7990	5500	4230	2770

CAL YR 1974 TOTAL 20744 MEAN 56.8 MAX 679 MIN 24 AC-FT 41150
WTR YR 1975 TOTAL 30305 MEAN 83.0 MAX 884 MIN 38 AC-FT 60110

PEAK DISCHARGE (BASE, 800 CFS).—Oct. 28 12200; 7200 c/s (6.27 m); July 29 (unknown) 4140 c/s (8.95 m).

NOTE.—No gage-height record Dec. 13 to Jan. 17; Jan. 22 to Feb. 24; June 19 to July 23; July 28 to Aug. 29.

9-405500 NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UTAH

LOCATION.--Lat 37°12'19", long 112°58'40", in SW¼NW¼ sec.22, T.41 S., R.10 W., Washington County, Hydrologic Unit 15010006, on right bank in Zion National Park, 0.2 mi (0.3 km) downstream from point of diversion of Springdale Canal, 0.5 mi (0.8 km) downstream from Pine Creek, and 1.9 mi (3.1 km) northeast of Springdale.

DRAINAGE AREA.--[illegible] mi² (906 km²), approximately.

PERIOD OF RECORD.--May 1913 to June 1914, June to November 1923, April to June, August and September 1925 (fragmentary), October 1925 to current year. Published as Pine Creek near Springdale 1913-14 (flow of Springdale Canal not included) and as Mukontuweap River near Springdale 1923, 1925-32.

GAGE.--Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 13, 1913 to June 30, 1914, nonrecording gage at site 3.2 mi (5.1 km) downstream at different datum. June 6, 1923 to Dec. 14, 1949, nonrecording gages at several sites within 0.8 mi (1.3 km) of present site at various datums.

REMARKS.--Records good. Figures given herein include Springdale Canal, which diverts water in NW¼NW¼ sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

AVERAGE DISCHARGE.--51 years, 98.5 ft³/s (2.789 m³/s), 71,340 acre-ft/yr (88.0 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,150 ft³/s (259 m³/s) Dec. 6, 1966, from rating curve extended above 2,000 ft³/s (56.6 m³/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.25 ft (3.124 m); minimum observed, 20 ft³/s (0.57 m³/s) July 31, 1963.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 1,240 ft³/s (35.1 m³/s) Feb. 9, gage height, 4.56 ft (1.390 m); minimum daily, 29 ft³/s (0.82 m³/s) Sept. 1-4.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Max	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Min	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A-ft	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] Total [illegible] Mean [illegible] Max [illegible] Min [illegible] AC-FT [illegible]
[illegible] Total [illegible] Mean [illegible] Max [illegible] Min [illegible] AC-FT [illegible]

1977, otherwise

09403500 NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UTAH

Oct '76 – Sept '77

LOCATION.—Lat 37°12'33", long 113°38'40", in SE 1/4NE 1/4 sec.22, T.41 S., R.10 W., Washington County, Hydrologic Unit 15010003, on right bank in Zion National Park, 0.2 mi (0.3 km) downstream from point of diversion of Springdale Canal, 6.3 mi (0.8 km) downstream from Pine Creek, and 1.9 mi (3.1 km) northeast of Springdale.

DRAINAGE AREA.—330 mi^2 (854 km^2), approximately.

PERIOD OF RECORD.—May 1913 to June 1914, June to November 1923, April to June, August and September 1925 (fragmentary), October 1923 to current year. Published as Zion Creek near Springdale 1913-14 (flow of Springdale Canal not included) and as Mukuntuweap River near Springdale 1923, 1925-32.

GAGE.—Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 13, 1913 to June 30, 1914, nonrecording gage at site 3.2 mi (5.1 km) downstream at different datum. June 6, 1923 to Dec. 10, 1949, nonrecording gages at several sites within 0.8 mi (1.3 km) of present site at various datums.

REMARKS.—Records good. Figures given herein include Springdale Canal, which diverts water in NW 1/4NW 1/4 sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

AVERAGE DISCHARGE.—52 years, 97.4 ft^3/s (2.758 m^3/s), 70,570 acre-ft/yr (87.0 hm^3/yr).

EXTREMES FOR PERIOD OF RECORD.—Maximum discharge, 9,150 ft^3/s (259 m^3/s) Dec. 6, 1966, from rating curve extended above 2,000 ft^3/s (56.6 m^3/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.25 ft (3.124 m); minimum observed, 20 ft^3/s (0.57 m^3/s) July 31, 1963.

EXTREMES FOR CURRENT YEAR.—Maximum discharge, 749 ft^3/s (21.2 m^3/s) Oct. 2, gage height, 3.37 ft (1.027 m); minimum daily, 23 ft^3/s (0.65 m^3/s) July 27, 29 and 30.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	42	45	42	41	42	44	49	36	42	34	27	30
2	247	45	42	40	41	42	49	36	42	35	27	28
3	77	45	43	45	39	42	55	37	39	51	27	29
4	44	44	44	44	43	42	72	36	40	50	27	29
5	41	43	43	44	42	40	88	36	40	46	27	29
6	39	42	44	41	41	41	87	36	41	47	26	29
7	39	43	42	38	41	37	80	38	43	41	26	29
8	39	42	42	37	41	36	72	34	42	38	26	29
9	39	42	43	37	42	39	63	36	42	35	26	29
10	39	41	43	38	42	36	58	39	46	35	26	32
11	39	43	42	39	42	47	59	38	40	36	29	32
12	40	41	42	39	42	49	55	38	38	38	29	36
13	39	41	44	40	42	47	54	36	35	35	41	35
14	38	43	43	39	45	44	56	63	37	34	36	33
15	38	49	45	39	44	45	53	52	37	35	29	33
16	39	46	46	38	45	49	49	48	37	42	32	31
17	38	46	44	38	44	48	42	42	37	50	122	30
18	38	45	44	41	42	44	42	41	36	42	46	31
19	40	39	43	41	42	48	41	41	35	38	32	31
20	40	38	42	41	42	47	42	40	35	38	26	31
21	42	37	43	42	46	45	40	40	34	44	26	32
22	43	37	41	44	46	46	41	40	34	37	26	32
23	44	36	40	43	41	48	40	39	34	31	42	33
24	45	35	41	42	42	42	39	47	35	26	95	32
25	44	34	41	40	39	43	37	210	36	26	42	32
26	45	37	41	42	40	44	38	75	35	26	33	32
27	45	34	42	40	44	42	39	59	46	23	32	33
28	44	32	45	41	42	44	38	72	33	26	32	33
29	45	33	43	40	---	43	39	65	34	23	33	33
30	46	39	43	40	---	47	37	53	33	23	34	34
31	46	---	41	40	---	48	---	44	---	27	31	---
TOTAL	1524	1217	1326	1253	1104	1359	1554	1543	1130	1102	1189	942
MEAN	49.3	40.6	42.7	40.4	42.3	43.8	51.8	49.8	37.9	35.5	35.8	31.4
MAX	247	49	46	45	46	49	88	210	46	51	122	36
MIN	38	32	40	37	39	36	37	34	33	23	26	28
AC-FT	3030	2410	2630	2490	2350	2700	3080	3060	2240	2190	2200	1870

CAL YR 1976 TOTAL 22747 MEAN 62.3 MAX 319 MIN 29 AC-FT 45220
WTR YR 1977 TOTAL 15254 MEAN 41.8 MAX 247 MIN 23 AC-FT 30260

1975/1977
Zion P

09403300 NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UTAH

LOCATION.—Lat 37°12'35", long 112°58'40", in SW1/4NW1/4 sec.22, T.41 S., R.10 W., Washington County, Hydrologic Unit 15010008, on right bank in Zion National Park, 0.2 mi (0.3 km) downstream from point of diversion of Springdale Canal, 0.5 mi (0.8 km) downstream from Pine Creek, and 1.9 mi (3.1 km) northeast of Springdale.

DRAINAGE AREA.—344 mi² (891 km²) (revised).

PERIOD OF RECORD.—May 1913 to June 1914, June to November 1923, April to June, August and September 1923 (fragmentary), October 1923 to current year. Published as Zion Creek near Springdale 1913-16 (flow of Springdale Canal not included) and as Mukuntuweap River near Springdale 1923, 1923-32.

GAGE.—Water-stage recorder. Altitude of gage is 3,970 ft (1,210 m) from topographic map. May 13, 1913 to June 30, 1914, nonrecording gage at site 3.2 mi (5.1 km) downstream at different datum. June 6, 1923 to Dec. 19, 1949, nonrecording gages at several sites within 0.8 mi (1.3 km) of present site at various datums.

REMARKS.—Records good. Figures given herein include Springdale Canal, which diverts water in NW1/4NW1/4 sec.22, T.41 S., R.10 W., for irrigation in vicinity of Springdale. Diversion above station for irrigation of about 1,400 acres (570 ha).

AVERAGE DISCHARGE.—53 years, 98.4 ft³/s (2.787 m³/s), 71,290 acre-ft/yr (87.9 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.—Maximum discharge, 9,150 ft³/s (259 m³/s) Dec. 6, 1966, gage height, 12.98 ft (3.956 m), from rating curve extended above 2,000 ft³/s (56.6 m³/s) on the basis of a drift measurement at gage height 6.71 ft (2.045 m), a slope-area measurement at gage height 10.25 ft (3.124 m); minimum observed, 20 ft³/s (0.57 m³/s) July 31, 1963.

EXTREMES FOR CURRENT YEAR.—Maximum discharge, 1,325 ft³/s (37.5 m³/s) Mar. 4, gage height, 4.66 ft (1.420 m); minimum, 22 ft³/s (0.62 m³/s) Dec. 20.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	33	35	38	38	54	487	214	683	407	57	67	71
2	34	36	39	36	51	592	246	632	378	56	65	71
3	34	36	42	45	53	341	277	749	347	55	67	71
4	35	35	40	53	54	238	302	792	306	54	57	71
5	35	36	40	51	57	461	511	640	277	54	58	74
6	35	38	39	136	93	282	645	483	257	53	56	76
7	36	37	62	43	111	116	401	481	237	52	59	75
8	38	38	39	41	77	96	269	402	217	51	61	79
9	29	33	34	45	173	98	258	519	197	58	61	76
10	38	36	38	63	511	96	241	638	177	48	68	67
11	29	37	37	62	111	143	262	681	166	49	62	43
12	38	37	39	53	79	138	293	731	156	48	61	41
13	38	37	36	44	68	75	341	798	147	48	78	41
14	38	37	39	58	77	76	291	877	138	46	68	45
15	31	38	48	142	58	76	372	856	119	46	67	69
16	31	37	48	68	68	76	394	748	118	45	66	54
17	31	37	34	79	52	75	248	594	101	43	66	48
18	32	38	69	69	58	74	219	562	96	59	63	46
19	32	39	38	69	58	72	263	595	93	48	63	45
20	34	36	38	64	68	67	328	628	86	46	66	45
21	39	37	38	55	61	67	347	639	83	46	64	45
22	36	44	43	58	68	72	303	647	78	46	67	46
23	34	48	44	59	60	82	354	642	76	64	62	46
24	34	42	42	43	61	147	459	580	70	53	61	46
25	34	42	38	41	62	167	514	509	66	55	61	47
26	34	41	39	48	63	286	768	468	65	65	61	48
27	34	42	46	58	61	452	734	432	62	69	62	46
28	35	48	59	49	87	222	707	487	68	79	61	46
29	36	38	58	54	---	211	711	423	68	72	68	44
30	36	41	48	52	---	197	645	437	58	67	61	44
31	36	---	59	57	---	202	---	426	---	69	68	---
TOTAL	1029	1140	1291	1809	2422	5011	11819	18603	4682	1713	1973	1666
MEAN	33.2	38.0	41.6	58.4	86.5	107	394	488	156	55.3	63.6	55.5
MAX	39	44	69	142	511	592	768	877	407	79	97	79
MIN	29	33	38	36	58	67	214	481	58	45	56	41
AC-FT	2040	2260	2560	3590	4800	11530	23440	36900	9290	3400	3910	3300

CAL YR 1977 TOTAL 14644 MEAN 40.1 MAX 210 MIN 23 AC-FT 29050
WTR YR 1978 TOTAL 53950 MEAN 148 MAX 877 MIN 29 AC-FT 107000

APPENDIX C

HYDROGEOLOGIC REPORT

HYDROGEOLOGIC REPORT

GROUNDWATER ALTERNATIVES FOR SPRINGDALE

for

CREAMER & NOBLE, INC.
Consulting Engineers
St. George, Utah

by

S. Bryce Montgomery
Geologist

May 1980

HYDROGEOLOGIC REPORT, GROUNDWATER ALTERNATIVES FOR SPRINGDALE

INTRODUCTION: It is ironic that a community whose name is derived from springs is now in need of deriving water by pump lift from wells. However, since the original spring water so plentifully obtained from the area which is now Zion National Park is now restricted in its more efficient development and conveyance to the town, other sources are being sought.

The engineering firm of Creamer and Noble, Inc. of St. George has asked the writer to investigate the potential of developing suitable ground water from the Little Creek Terrace and the Gould Wash area bounding it to the north near Gooseberry Mountain. This is at an elevation of 4600 - 4900 feet and approximately eight direct miles southeast of Springdale.

On April 11, 1980, in the company of Reed Noble and Frank Seegmiller, the writer field examined the proposed area. Earlier in the day we also examined another area proposed by the writer in the mouth of Parunuweap Canyon (East Fork of the Virgin River). This was done in the company of Mr. Ardell De Mill, the land owner in this area.

Other groundwater potentials have been previously investigated at Springdale. The only practical aquifer beneath the town besides shallow stream valley alluvium, is the Triassic age Shinarump Sandstone. Two wells have been drilled into the Shinarump Sandstone aquifer, but the produced water is high in sulfates, although it could be utilized for culinary purposes providing an adequate volume of higher quality, low mineral content water is diluted with it.

In addition to the examination of over 80 well drillers logs in the State Engineer's Office, personal consultation was made with Mr. E. J. Graff of Hurricane, Utah, owner of several wells in the Little Creek Terrace area, and Mr. Ardell DeMill, land owner in the Parunuweap Canyon area. Also, reference has been made to the following publications:

Cook, Earl F. (1960), "Geologic Atlas of Washington County," Bulletin No. 70, Utah Geological and Mineralogical Survey, and the U. Utah College of Mines and Mineral Industries;

Gregory, Herbert E. (1950), "Geology and Geography of the Zion Park Region, Utah and Arizona," Prof. Paper 220, U. S. Geogical Survey;

Digerness, D. S. and Gates, R. (1975), "Springdale NW 711 preliminary Topographic Map," 7.5 Min Quadrangle, Scale 1:24,000;

U.S. Geological Survey (1957), "Topographic Map of Zion National Park (Zion Canyon Section), Scale 1:31,680; and La Verkin 4 SW Quadrangle, LaVerkin 4 SE Quadrangle, LaVerkin 4 NW Topographic Maps, 7.5 Min., Scale 1:24,000.

LITTLE CREEK TERRACE AREA: This general area receives an average annual precipitation of from 10 - 16 inches. Thus, the several wells already drilled in the area have very limited annual recharge to the existing groundwater aquifers.

This terrace area is principally "held-up" by the capping Shinarump Conglomeratic Sandstone of Triassic age. It is white-yellow-brown, 75 - 200 feet thick and jointed. Its regional dip is to the east a few degrees but near the southward extension of the Grafton Fault it dips 8° eastward.

Precipitation falling directly on or running over the outcropping edges and terrace surfaces of the Shinarump Sandstone, in part, infiltrates to recharge the aquifer. However, since most of the outcropping Shinarump Sandstone is now elevated as the capping rock of both the Gooseberry Mountain and the Little Creek mesas, the aquifer here tends to drain off to the outer edges, but generally down-dip to the east. Irregularities in the thickness and base of the sandstone provides a limited amount of groundwater storage on these high mesas. Presently the Town of Virgin is draining water out of such groundwater storage from a horizontal well drilled into the Shinarump Sandstone from the north edge of Gooseberry Mountain. Although the initial flow from this horizontal well was reported to be 300 gpm, as the drainage cone depression has widened with time from discharge, the flow has diminished to much less.

Near and east of the Grafton-Little Creek Fault shown on the attached map, the Shinarump dips beneath the surface up to 8° eastward from horizontal due to local flexuring and then dips gently eastward under the Eagle Crags and Canaan Mountain areas. The eroded and northern edge of this sandstone bed is exposed in the cliffs south of Rockville where ground water is spilling from it as the Rimrock Spring and seeps. Rockville has a well drilled into the Shinarump Sandstone near Rimrock Spring where it initially produced about 50 gpm of good quality water.

In the bench area east of the Grafton-Little Creek Fault there have been several wells drilled into the Shinarump Sandstone aquifer, where it is encountered at reported depths of 40 - 225 feet, the deeper depths being the fartherest east.

Reported yields, used principally for irrigation and stockwatering, from wells completed in the Shinarump Sandstone within the Little Creek area are from 3 - 175 gpm. The static water level is 57 - 177 feet from ground level. Water quality is apparently good but one stock watering well with windmill discharge had a high sulfate and iron taste. This well could be partially completed within the overlying Chinle Shale section which is high in sulfates. Fractures and joints within the Shinarump Sandstone greatly enhance its aquifer characteristics, and best yielding wells are found within such zones.

Within the Little Creek - Gould Wash area there have been several wells drilled mainly for E. J. Graff into alluvium composed of clay, silt, sand, gravel, and some cinders. The aquifer is within the sands and gravels which have been derived from the erosion of the Shinarump Conglomeratic Sandstone found on both the south and north mesas. The cinders have been derived from the eruption and erosion of the Little

Creek Knoll volcanic cone and associated lava flow. These wells reveal up to 282 feet of alluvium within which sand and gravel beds up to 30 feet thick have been reported. These wells with the thickest section of alluvium are located within Sections 19, 29 and 30, T42S, R11W, and Sections 23 and 24, T42S, R12W, of the Little Creek - Gould Wash valley, between Gooseberry Mountain and Little Creek Terrace. The static water level stands between 27 - 145 feet from ground serface. Mr. E. J. Graff reports that the best yielding well, apparently in Section 19 or 24 produces up to 400 gpm and is used for sprinkler irrigation.

The lateral extent of the valley fill of alluvium which forms the aquifer storage for this ground water is one mile or less in width and is approximately 4 - 5 miles long. It apparently was deposited within a deep ravine in association with the extrusion of the Little Creek Knoll volcanoe and associated erosion of the bounding Shinarump Sandstone mesas.

The drainage area, which receives precipitation to recharge this alluvial aquifer, extends over most of the Little Creek Mountain Terrace to the south, the Little Creek drainage to the southeast, the bench area over to the Canaan Mountain to the east, and the southern part of the Gooseberry Mountain Mesa to the north, a total of approximately 40 square miles. It is because of this large gathering area of precipitation being funneled into the limited Little Creek - Gould Wash, alluvial filled valley that gives this alluvial aquifer its relatively high yielding capacity. However, the small storage area of the valley fill limits the amount of water that can be held in groundwater storage there between storms. Thus, especially in dry years as wells produce throughout the summer on a continual basis the groundwater levels will drop proportionately.

Underlying the alluvial aquifer within the Gould Wash - Little Creek drainage, and the Shinarump Sandstone is the Triassic age Moenkopi formation which consists of up to 1600 feet thickness of interbedded, reddish -brown and yellowish, platy, thin-bedded clayey and silty, gypsiferous and calcareous sandstone, some thin limestone, and shales. The units are generally of low porosity and permeability although some of the sandstones and limestones do produce small yields of ground water that is usually high in calcium sulfate. Such producing wells have been drilled in the Short Creek area at the southest side of Little Creek Mesa within Sections 29, 30, 31, 32 and 34, T43S, R11W, SLB & M.

PARUNUWEAP CANYON - SHUNESBURG AREA: This area has been suggested by the writer for consideration because of the high average, annual precipitation that exists over the contributing drainage area (16 - 40 inches), the closer distance to Springdale Town, and the potentially high quality and quanity of ground water available. In addition, the thick Navajo Sandstone formation (up to 2000 feet) is receiving, storing and spilling high quality ground water to the East Fork of the Virgin River, continuously.

Because of the steeply eroded Parunuweap Canyon and the shallow alluvial fill at the entrance of the East Fork of the Virgin River, the big concern is: "Where is the groundwater storage formation that will receive, store and release the plentiful, high quality water supply to new wells?" The Shinarump Sandstone aquifer is present at a reasonable

depth in the mouth of the East Fork of the Virgin River and could be drilled into and produced. But, the question is whether the ground water produced here would be of any better quality than that recently produced from the Shinarump Sandstone aquifer, by the two wells drilled into it within the Springdale Town area. There appears to be no discontinuity of the sandstone aquifer between these two areas.

Thus, the search was made in the field for an area within the East Fork of the Virgin River that would possibly contain a sufficient alluvial section containing aquifer gravels, in which wells could be reasonably drilled and produced. Such an area was tentatively identified at the junction of South Creek and Shunes Creek with the East Fork of the Virgin River, immediately west of the old Shunesburg Townsite, in the NE¼ NE¼ Sec. 9. However, upon further consideration of the area, it appears that an equally good or getter location is in the mouth of Parunuweap Canyon, immediately east of the old Shunseburg Townsite, and west of the Zion National Park boundary. It is not known how thick the alluviaum is here in these two proposed areas, but it is obvious that there are good aquifer gravel deposits within it and plenty of continuous recharge of high quality water.

CONCLUSIONS AND RECOMMENDATIONS: Ground water of apparent culinary quality can be produced from either or both the Shinarump Sandstone and alluvial aquifer within the Little Creek - Gould Wash area. However, the yields are limited because of the nature, storage size and average annual recharge to these aquifers. Furthermore, unless some existing water rights are purchased from owners of wells in the area, further appropriations of ground water in quanities sufficient for the needs of Springdale, from the aquifers will likely diminish needed supplies for the existing wells. However, if this alternative is pursued the writer recommends that new wells drilled into the alluvial aquifer be completed to conform to Utah Board of Health Standards, within the N½ NW¼ Sec. 30; the SW¼ SW¼ Sec. 19, T42S, R11W; and the E½ SE¼, NW¼ SE¼, and S½ NW¼ Sec. 24, T42S, R12W, SLB & M. These wells should be drilled completely through the alluvial section to the top of the Moenkopi Formation with cable tools to an approximate depth of 250 feet. Drill cutting samples should be collected every 5 feet and change in formation, and stored in properly marked containers of at least 3-pound size. Surface casing of 12-inch dameter without casing shoe should be set to 100 feet depth, through which 8-inch diameter casing with casing shoe will be set to the total depth. After examination of the drill cuttings by a qualified person and in correlation with the drillers log the 8-inch casing should be perforated with a Mills Knife of proper width at selected intervals. An alternate to this is to set 6-inch diameter screens through the 8-inch casing and pull the 8-inch casing back. After block-surging the perforations fully to develope the well, a pumping test with a line-shaft pump having a variable speed engine at the surface should be conducted of at least 24 hour duration.

Following the pumping test the 8-inch casing should be sealed between the bottom of the 12-inch casing at 100-feet depth, and cement grout placed between the two casings as the 12-inch casing is pulled back from the hole and removed.

If the Shinarump Sandstone aquifer is pursued on the Little Creek Bench, it is recommended that the wells be drilled within the E½ E½ Sec. 28, E½ E½ Sec. 32, and the W½ Sec. 33, T42S, R11W, SLB & M, into the top 10 feet of the Shinarump Sandstone with either air rotary or cable tools with a 12-inch diameter hole. At this point 8-inch diameter casing should be set in the hole with centralizers and cement grouted completely around from bottom to ground surface, using a tremie pipe on the outside of the casing or pressure grouting through the center of the casing and up-around the outside to ground surface. After the cement has set for at least 24-hours, the Shinarump Sandstone should be drilled completely through to the top of the Moenkopi (approximately 250 - 350 feet), using air rotary or cable tools, completing open-hole. The well should be surged clean followed by pump testing for at least 24 hours with a line -shaft pump and variable speed engine at ground surface. Drill cutting samples should be collected for each 5-foot interval and change in formation and stored in properly labled containers.

It is the writer's recommendation that the alluvial aquifer in the mouth of Parunuweap Canyon be pursued. Two locations are recommended as follows:

No. 1 - E. 6860 ft. and N. 400 ft., and

No. 2 - E. 4630 ft. and S. 350 ft., both from the SW Cor. Sec. 4, T42S, R10W, SLB & M.

However, it is urged that either seismic refraction surveys be conducted in these proposed sites and or small diameter test holes be drilled to confirm the thickest section of alluvium and the materials present at depth, before drilling production wells. The No. 1 site is on the north side and the No. 2 site is on the south side of the East Fork of the Virgin River. The production wells should be drilled with cable tools to the top of the underlying bedrock of the Moenave Formation. Surface casing of 16-inch diameter should be used with a drive shoe, collecting 5-pound size samples each 5 feet and storing them in properly labled containers. After examination of the drill cuttings by a qualified person and correlating them with the driller's log, the well should be completed with setting a 12-inch diameter screen with proper slot width through the 16-inch casing and pulling the 16-inch casing back. After block-surging the screen and cleaning the well, it should be pump tested with a line-shaft pump using a variable speed engine at the surface for at least 24 hours. The well should then be cement grouted from about 100 feet to ground surface, using a tremie pipe between the 12-inch casing attached to the screen and the 16-inch casing.

The estimated cost to drill and pump test each well at the Shunsburg Townsite area , to the point of equipping with a production pump is $25,000 - $30,000. This does not include necessary road work to the sites, installation of production pump, power lines and conveyance pipeline to Springdale.

The estimated cost to drill and pump test each well at the Little Creek Terrace area, to the point of equipping with a production pump, is approximately $20,000. This does not include costs of completing the well and associated conveyance pipeline to Springdale.

Respectfully submitted,

S. Bryce Montgomery

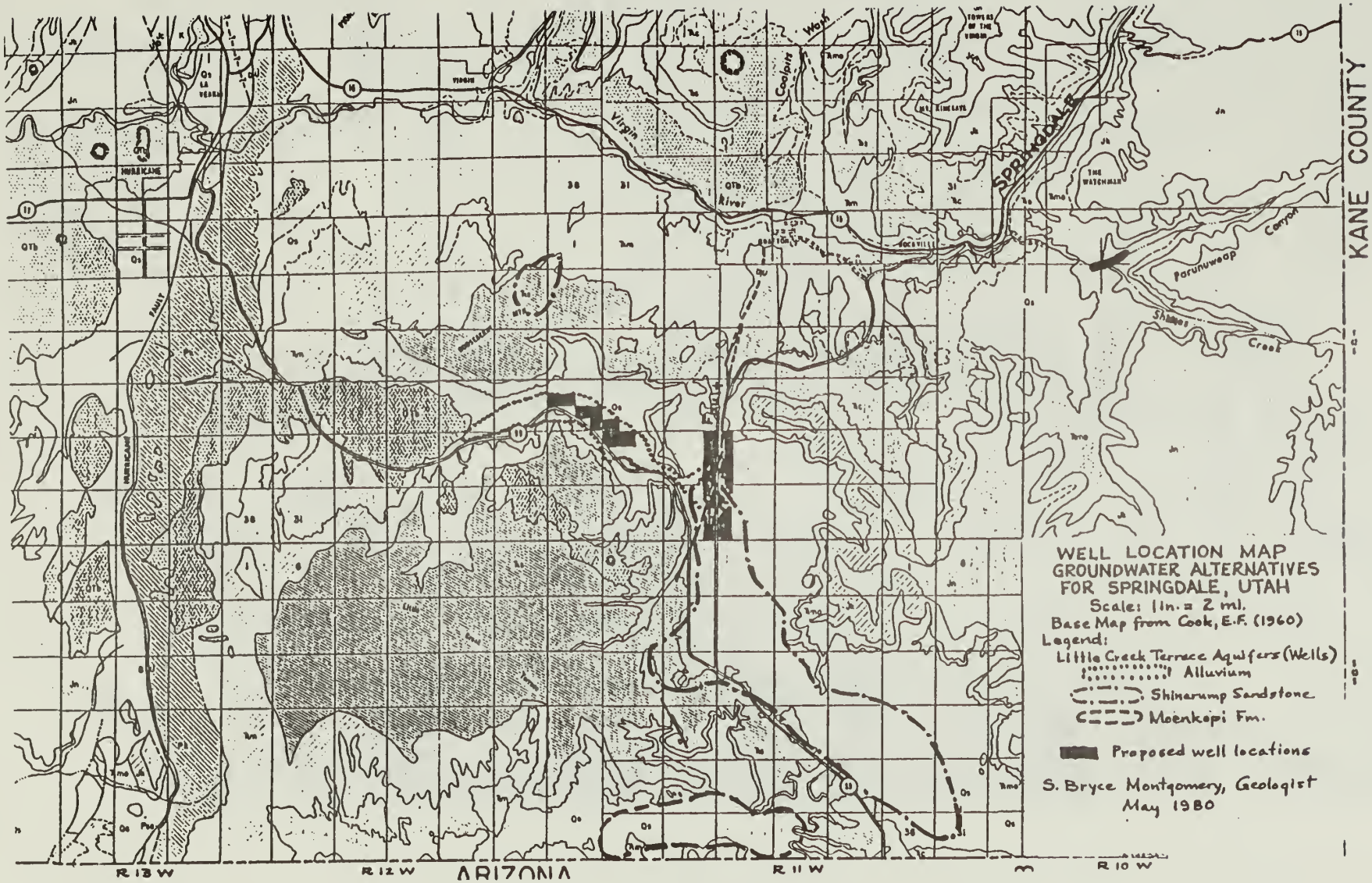
Attachment: Well Location Maps

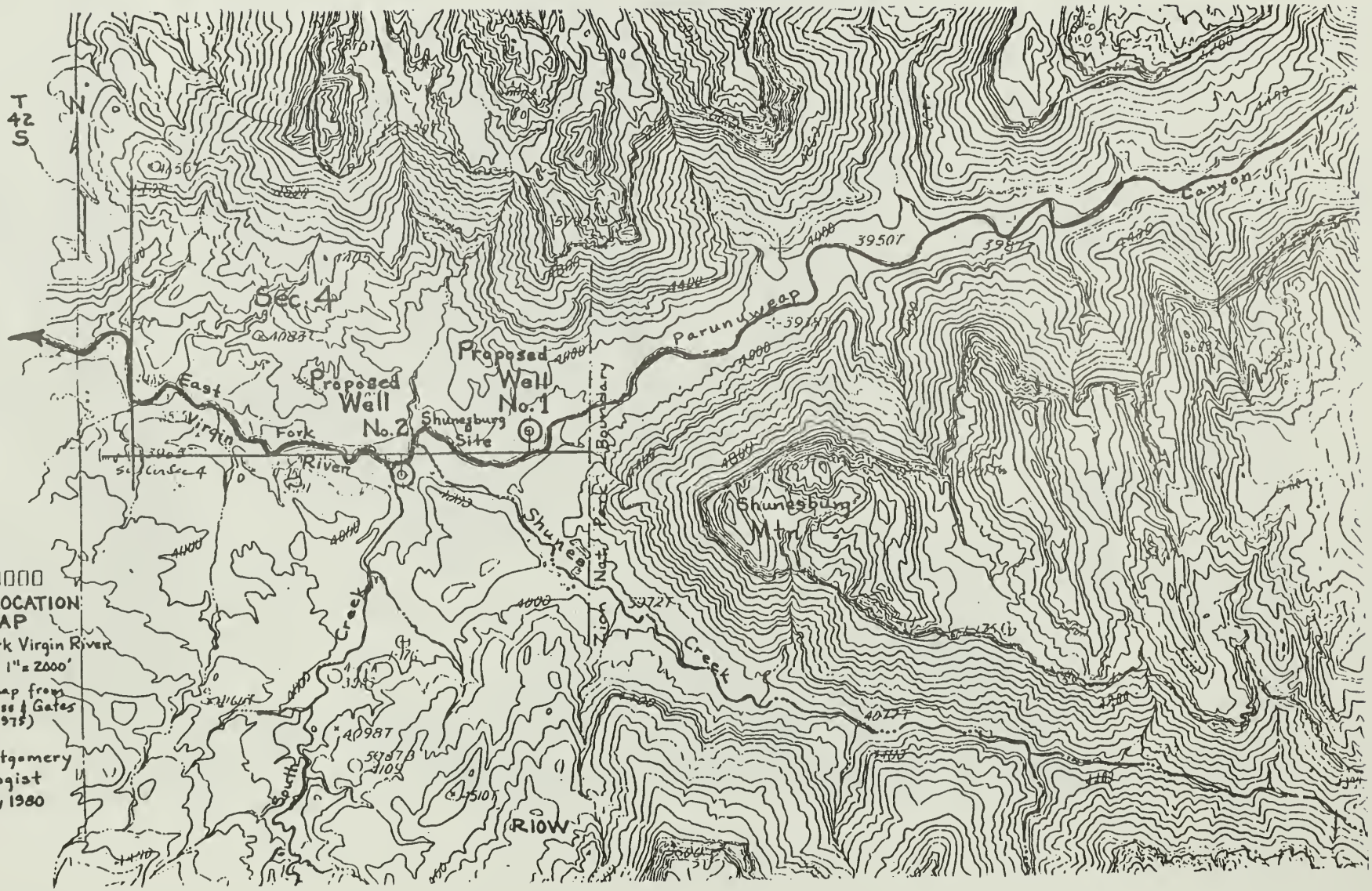
S. Bryce Montgomery
Geologist

3512 South 100 East
Bountiful, Utah 84010

Telephone 295-8592

May 5, 1980


WELL LOCATION MAP
GROUNDWATER ALTERNATIVES
FOR SPRINGDALE, UTAH
Scale: 1 in. = 2 mi.
Base Map from Cook, E.F. (1960)
Legend:
Little Creek Terrace Aquifers (Wells)
Alluvium
Shinarump Sandstone
Moenkopi Fm.
Proposed well locations
S. Bryce Montgomery, Geologist
May 1980
KANE COUNTY
ARIZONA
R 13 W
R 12 W
R 11 W
R 10 W
SPRINGDALE
Virgin River
Coolpits Wash
Parunuweap Canyon
Shinnes Creek
HURRICANE FAULT
HURRICANE
VIRGIN
LA VERKIN
THE WATCHMAN
TOWERS OF THE VIRGIN
MT. KINESAVE
ROCKVILLE
GRAFTON
Jn
Jk
Qs
Qtb
Tm
Tmo
Tc
Ts
Pe
38
31


T
42
S
N
Sec. 4
Proposed
Well
No. 2
Proposed
Well
No. 1
Shunesburg
Site
East
Fork
Virgin
River
Parunuweap
Canyon
Shunesburg
Mtn.
Shunes
Creek
Zion Nat. Park Boundary
South
Creek
R10W
100000
WELL LOCATION
MAP
East Fork Virgin River
Scale: 1" = 2000'
Base map from
Digerness & Gates
(1975)
S.B. Montgomery
Geologist
May 1980

APPENDIX D

COST SUMMARY

and

DETAILED COST FIGURES

No Action - Continue Use of Present System with No Additional Changes

Alternative A - Continue Use of Present System with Additional Conservation Measures

Alternative B - Additional Springs and Well Development

Alternative C - River Treatment Inside Park for National Park Service and Town

Alternative D - River Treatment Outside Park for Town Only

Alternative E - River Treatment Outside Park for National Park Service and Town

Alternative F - Well Supply from Hurricane for National Park Service and Town

Alternative G - Well Supply from Plains for National Park Service and Town

Alternative H - Well Supply from Plains for Town Only

Alternative I - Well Supply from Shunesburg for National Park Service and Town

Alternative J - Well Supply from Shunesburg for Town Only

COST ESTIMATES

Explanation of the cost estimates presented in Appendix D and the methods of calculation are as follows:

Initial Capital Cost, NPS

The actual initial capital cost to the National Park Service is based on the proportionate share of water consumption and facility use. Cost includes 25 percent for contingencies, legal, fiscal and engineering fees (see Column 1 of Alternative Cost Breakdown).

Initial Capital Cost, Springdale

The actual initial capital cost to Springdale is based on the proportionate share of water consumption and facility use. Cost includes 25 percent for contingencies, legal, fiscal and engineering fees (see Column 3 of Alternative Cost Breakdown).

Initial Annual O & M

Operation and maintenance costs in this column are the total initial (1980) costs for the alternative.

Average Annual O & M, 1990

Projected operation and maintenance costs for 1990 are multiplied by 2.17, which assumes an annual inflation of 9 percent from today's costs.

ASSUMPTIONS

1. NPS and town split all joint facilities on the following basis: 30 percent NPS/70 percent Springdale. This was derived using anticipated use of 200 gpm for NPS and 450 gpm for Springdale.

2. NPS Depreciation Bond on Mechanical Equipment - 15 years
   Pipeline - 30 years
   Land, Water Rights - 40 years
   Reservoirs - 20 years

3. O & M costs may be reduced by one-half if existing springs used on the applicable alternatives.

4. An additional $270,000 capital cost or $62,000 annual cost must be added to all Springdale alternatives for Distribution System Improvements except on Alternatives F and G when only $59,000 capital cost and $1,400 annual cost due to Park participation through town.

5. Average O & M costs based on year 1990 assuming 9 percent inflation from today's costs.

6. Initial power consumption and cost based on 200 gpm for each NPS and town. Average power consumption based on 400 gpm for each. All costs computed for 180 days only to assume average annual bond.

7. Power computed on 0.06¢ per KWH. Power for 1990 based on 9 percent inflation rate.

8. All town annual costs assume 60 percent grant and remainder on loan for 5 percent for 40 years.

COST SUMMARY

Costs for the 11 alternatives vary widely. The following chart lists the alternatives in order of their capital costs.

CAPITAL COSTS

Alt. F	Well at Hurricane	$2,359,000
Alt. G	Wells on the Plains (NPS & town)	$1,669,000
Alt. C	Treatment Plant inside the Park	$1,578,000[1]
Alt. E	River Treatment at Springdale (NPS & town)	$1,303,000
Alt. B	Spring Development inside the Park	$1,286,000[1]
Alt. I	Well at Shunesburg (NPS & town)	$1,152,000[2]
Alt. H	Wells on the Plains (Town only)	$ 928,000
Alt. D	River Treatment at Springdale (Town only)	$ 919,000
Alt. J	Well at Shunesburg (Town only)	$ 712,000[2]
Alt. A	Present System with Conservation Measures	$ 504,000
Alt. AA	No Action	No capital costs

[1]Does not include costs associated with construction in floodplain

[2]Does not include water rights acquisition costs

Costs for construction range from over two million dollars to approximately one-half million. Three of the alternatives involve treatment plants on the Virgin River. Four of the alternatives involve well systems. Operation and maintenance costs can greatly increase the total amount needed to keep the system functioning.

The following chart shows the estimated costs for operations of the alternatives in 1980 dollars.

OPERATIONS AND MAINTENANCE COSTS (1980)

Alt. E	River Treatment at Springdale (NPS & town)	$85,000
Alt. F	Well at Hurricane	$71,000
Alt. C	Treatment Plant inside the Park	$67,000
Alt. D	River Treatment at Springdale (Town only)	$60,000
Alt. B	Spring Development inside the Park	$25,000
Alt. I	Well at Shunesburg (NPS and town)	$21,600
Alt. J	Well at Shunesburg (Town only)	$21,600
Alt. A	Present System with Conservation Measures	$21,000
Alt. AA	No Action	$18,000
Alt. G	Wells on the Plains (NPS and town)	$12,500
Alt. H	Wells on the Plains (Springdale only)	$ 9,000

Alternative F (Well at Hurricane) is the most expensive alternative in terms of capital costs because of the distance involved from the water supply to Springdale. It would cost $1,144,000 just for pipe in this alternative. This is nearly as expensive as the total cost of many of the other alternatives and is more expensive than some of the alternatives listed. Cost of operating this system would be approximately $71,000 a year in 1980 dollars. These costs are because of the anticipated high cost of electricity to pump water from Hurricane. Alternative E is the only alternative that is more expensive to operate than the well system at Hurricane.

Alternative F would produce all the water Springdale is looking for. If this alternative were selected, additional cost would be necessary to floodproof the water line from the town of Virgin to Springdale to comply with Executive Order 11988.

Alternative G (Wells on the Plains - NPS and town) involves drilling two wells on the Plains area south of Rockville and constructing approximately 12.5 miles of pipeline. The O & M costs are estimated at $12,500 a year. With a well system, very little treatment would be necessary and since a gravity flow could be generated, no pumping

costs would be incurred. This alternative might not be able to supply all the water needed, as the recharge area is very small. (Hydrogeologic Report, S. B. Montgomery, May 1980)

Alternative C (Treatment Plant inside the Park) is the next most expensive choice at $1,578,000 for capital costs. This alternative involves considerable construction of a treatment plant, infiltration gallery, backwash ponds and replacement of all the main water line now in place in the Park water system. Because a treatment plant is involved, operation and maintenance costs are estimated in 1980 dollars at $67,000 a year. Most of the expenses are operators' salaries because of the necessity of operating the plant on a year-round basis. This alternative would meet Springdale's water needs. If this alternative were selected, construction within the floodplain would increase the costs shown to comply with Executive Order 11988.

Alternative E (River Treatment at Springdale - NPS and town) is a treatment plant located in Springdale to provide water for both the town and the Park. Costs would be high for construction of a treatment system and associated facilities and transport lines. Pumping would be required to get the water from the river and to the Park. Subsequently, O & M costs will be high for plant operators, electricity and maintenance. Estimated 1980 costs for running the plant are $85,000 a year. This alternative would provide all the water Springdale wants. The site selected would determine if the alternative would need to comply with Executive Order 11988.

Alternative B (Spring Development inside the Park) would develop a spring near the Temple of Sinawava parking area. Construction would include over 8.5 miles of new pipeline with the possibility of several more river crossings than the cost estimates show. If the river crossings are needed to get around the hill near Angels Landing, the capital costs would be higher than presently shown. O & M costs are estimated at $25,000 a year. If this water source is a true spring, relatively little treatment would be necessary and no electricity would be needed because of a gravity flow concept. This alternative would not provide as much water as Springdale desires, so costs shown are high for the amount of water available. Selection of this alternative would require compliance with Executive Order 11988, which would increase costs over those shown.

Alternative I (Well at Shunesburg - NPS and town) involves drilling a well on the south shore of the East Fork of the Virgin River. Nearly 7.0 miles of pipeline would be laid with two river crossings. O & M costs are estimated at $21,600 a year. A good portion of this cost is electricity for the pumping operations. Treatment other than chlorination should not be necessary. This alternative would

provide all the water Springdale wants. Construction in the floodplain would require compliance with Executive Order 11988 if Federal participation is involved. Such compliance will increase capital costs over those shown.

Alternative H (Wells on the Plains - Town only) is similar to Alternative G except it would supply only the town of Springdale. Water line construction would be the same as in Alternative G. O & M costs for 1980 are $9,000 and $19,500 for 1990. The same limitations apply in relation to the water supply on the Plains.

Alternative D (River Treatment in Springdale - Town only) would involve building a water treatment plant in Springdale for the town alone. Major costs are for the plant, associated ponds and pumping stations. Little in the way of new pipe is needed. O & M costs include the expense of plant operators and electrical costs for pumping. These operation costs are estimated at $60,000 a year. This alternative would provide the amount of water Springdale is looking for.

Alternative J (Well at Shunesburg - Town only) is the same as Alternative I with the exception that there would be no Park participation in the project. This would remove the one million gallon storage tank from the Park, which would reduce capital costs by $200,000. O & M costs would remain about the same as for Alternative I. Compliance with Executive Order 11988 would apply to Alternative J if Federal funding is sought.

Alternative A (Present System with Conservation Measures) would maintain the present Park system with the majority of capital costs going into water line replacement and construction of additional water storage. O & M costs are estimated at $21,000 a year. Electrical costs are part of this expense because of Springdale pumping one of their wells. This alternative would supply approximately 75 gpm more than the amount Springdale is getting from the Park at the present time.

Alternative AA (No Action) would require no capital investment. The present system would be maintained and replaced as needed. O & M costs are presently $18,000 a year. This alternative would not provide the amount of water Springdale desires. Total capacity of the Park system is less than the amount Springdale is seeking.

CAPITAL AND O & M COSTS

	CAPITAL COSTS NPS	CAPITAL COSTS SPRINGDALE	TOTAL COSTS ALTERNATIVE	O & M COSTS (1980)	O & M COSTS (1990)
No Action Alternative AA	-0-	-0-	-0-	$18,000	$ 39,000
Continue Present System With Conservation Measures Alternative A	$320,000	$ 184,000	$ 504,000	$21,000	$ 45,500
Spring Development in the Park Alternative B	$451,000	$ 835,000	$1,286,000	$25,000	$ 54,000
Water Treatment Plant in the Park Alternative C	$555,000	$1,023,000	$1,578,000	$67,000	$145,000
Water Treatment Plant in Springdale Alternative D	-0-	$ 919,000	$ 919,000	$60,000	$130,000
Water Treatment Plant in Springdale for Town and NPS Alternative E	$516,500	$ 786,500	$1,303,000	$85,000	$184,000
Well in Hurricane Alternative F	$836,000	$1,523,000	$2,359,000	$71,000	$154,000
Wells on Plains for Town and NPS Alternative G	$629,000	$1,040,000	$1,669,000	$12,500	$ 27,000
Wells on Plains for Town Only Alternative H	-0-	$ 928,000	$ 928,000	$ 9,000	$ 19,500
Well at Shunesburg for Town and NPS Alternative I	$474,000	$ 678,000	$1,152,000	$21,600	$ 69,500
Well at Shunesburg for Town Only Alternative J	-0-	$ 712,000	$ 712,000	$21,600	$ 69,500

SPRINGDALE TOWN-ZION NATIONAL PARK WATERWORKS FACILITIES

Summary of Water Quality, Quantity and Energy Requirements

Alternatives	Existing Flow Available/If Used (gpm)	Flow from Sources (gpm)	Total Flow Available (gpm)	Water Quality	Energy Consumption Initial KWH/yr.	Energy Consumption 1990 KWH/yr.
A	281	City Well 75	356	Spring-Excellent Well-Unacceptable Mix-Marginal	51,000	51,000
B	281	New Spring 250 Existing Wells 150	681	Spring-Excellent Well-Unacceptable Mix-Marginal but Acceptable	0	34,000
C	Abandon	650	650	Good	67,000	100,000
D	281	450	731	Good	93,000	180,000
E	Abandon	650	650	Good	267,000	416,000
F	Abandon	650	650	Good	800,000	1,000,000
G	Abandon	650	650	Marginal	0	0
H	281	450	731	Spring-Good Wells-Marginal	0	0
I	Abandon	650	650	Marginal	168,500	432,000
J	281	450	731	Marginal	168,500	432,000

Assumption for Power:

Initial Demand	Park = 200 gpm	Springdale = 300 gpm
1990 Demand	Park = 200 gpm	Springdale = 400 gpm

CREAMER & NOBLE, INC.

CONSULTING ENGINEERS

Engineer's Preliminary Estimate

'ROJECT _____ Project No. _____

_____ Date _____

)WNER _____ Sheet _____ OF _____

Culinary System in Town Estimate by _____

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	8" D.I. Pipe (To Bumblebery)	L.F.	5,500	12.00	66,000.00
2	6" D.I. Pipe (To Eagles Nest)	L.F.	11,000	8.00	88,000.00
3	Pressure Reducing Station	L.S.			15,000.00
4	Fire Hydrants	EA	32	1,000.00	32,000.00
5	Connection	EA	150	100.00	15,000.00
	Subtotal				216,000.00
	25% Engineering, Legal Fiscal				54,000.00
	TOTAL				$270,000.00

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park

Alternative A

OWNER

Continue with Existing System with Additional Conservation Measures

Project No.

Date

Sheet OF

Estimate by

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
	Line Replacement in Park				
1	8" D.I. Pipe	L.F.	16,000	16.00	256,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				64,000.00
	TOTAL				320,000.00
	Additional Storage				
2	Springdale - 500,000 gallon Tank	L.S.			125,000.00
	Subtotal				125,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				31,000.00
	TOTAL				156,250.00
	Mix one existing Springdale Well				
3	Pump Station	L.S.			12,000.00
4	4" Pump Line	L.F.	2,500	4.00	10,000.00
	Subtotal				22,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				5,500.00
	TOTAL				27,500.00
	TOTAL				504,000.00

ALTERNATIVE A

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Town Annual Debt Service
1	256,000	8,500				
2			125,000			
3			12,000			
4			10,000			
Subtotal	256,000	8,500	147,000			
+25%	64,000	2,100	37,000			
TOTAL	320,000	10,600	184,000	110,400	73,600	4,300

NOTE: The operation and maintenance for Alternative A will approximately equal the O & M for the existing systems except that an additional $3,000 will be required for Springdale Town for the new well pump station.

CREAMER & NOBLE, INC.

CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park Water — Project No.

Alternative B — Date 1-20-79

OWNER — Sheet ___ OF ___

Additional Spring Development — Estimate by RSC

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
	SPRING DEVELOPMENT				
1	8" D.I. Pipe (To Brown Tank)	L.F.	25,000	16.00	400,000.00
2	8" D.I. Pipe (To Park Boundary)	L.F.	16,000	16.00	256,000.00
3	Spring Development	L.S.			25,000.00
4	River Crossing	EA	2	30,000.00	60,000.00
5	Reservoir 1 m.g	L.S.			200,000.00
			Subtotal		941,000.00
	WELL DEVELOPMENT				
6	Equip Wells	EA	2	12,000.00	24,000.00
7	4" Pipeline	Ln.Ft.	5,000	4.00	20,000.00
			Subtotal		985,000.00
	25% Contingencies, Engineering, Legal, Fiscal				246,000.00
			Subtotal		1,231,000.00
8	Water Rights				55,000.00
			TOTAL		1,286,000.00

ALTERNATIVE B

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Town Annual Debt Service
1 30/70%	120,000		280,000			
2 40/60%	102,000	3,400	154,000			
3 30/70%	7,500		17,500			
4 30/70%	18,000	600	42,000			
5	100,000	5,000	100,000			
6			24,000			
7			20,000			
Subtotal	347,500	9,000	637,500			
+25%	87,000	2,300	159,000			
8	16,500		38,500			
TOTAL	451,000	11,300	835,000	501,000	334,000	19,500

NOTE: Line from Spring to Brown Tank carries new spring water only.

(1) Proposal by Park Service to share cost of Items 1, 3 and 4 on a cost basis of 1/3 / 2/3.

(2) Item 5 may change according to the NPS evaluation on the need for additional storage.

ALTERNATIVE "B"

Operation & Maintenance

Initial

1.	Salaries (¼ time operator)	5,000
2.	Utilities	
	a. Well Pump Station	
3.	Chlorination Chemicals	1,000
4.	Professional Maintenance	
5.	Parts & Materials	1,000
6.	Existing O & M	12,000
	Total	19,000

1990

1.	Salaries	7,000
2.	Utilities	
	a. Well Pump Station	1,000
3.	Chlorination Chemicals	1,000
4.	Professional Maintenance	1,000
5.	Parts & Materials	3,000
6.	Existing O & M	12,000
	Total @ 1980	25,000
	Total @ 1990	54,000

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park Water
Alternative C

Project No.
Date
Sheet OF

OWNER
WTP in Park for Springdale and NPS

Estimate by

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Inlet Structure	L.S.			50,000.00
2	10" Inlet Line	L.F.	5,500	16.00	88,000.00
3	Treatment Plant (650 gpm)	L.S.			400,000.00
4	10" Line to Tank	L.F.	5,500	16.00	88,000.00
5	8" Line Tank to Park Boundary	L.F.	16,000	16.00	256,000.00
6	1.0 MG Reservoir	L.S.			200,000.00
7	Backwash System	L.S.			100,000.00
	Subtotal				1,182,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				296,000.00
	Subtotal				1,478,000.00
8	Water Rights				100,000.00
	TOTAL			*	1,578,000.00

* Does not include cost of flood protection.

ALTERNATIVE C

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Town Annual Debt Service
1 30/70%	15,000	1,000	35,000			
2 30/70%	26,400	1,800	61,600			
3 30/70%	120,000	8,200	280,000			
4 30/70%	26,400	900	61,600			
5 40/60%	102,000	4,300	154,000			
6 50/50%	100,000	5,000	100,000			
7 30/70%	30,000	2,100	70,000			
Subtotal	419,800	23,300	762,200			
+25%	104,950	5,800	190,550			
8	30,000	750	70,000			
TOTAL	554,750	29,900	1,022,750	589,800	393,200	22,900

ALTERNATIVE "C"

Operation & Maintenance

Initial

1.	Salaries (2 full time operators)	40,000
2.	Utilities	
	a. Treatment Plant	3,000
	b.	
3.	Chemicals	2,000
4.	Professional Maintenance	4,000
5.	Parts & Materials	5,000
	Total	54,000

1990

1.	Salaries	40,000
2.	Utilities	
	a.	7,000
	b.	
3.	Chemicals	4,000
4.	Professional Maintenance	8,000
5.	Parts & Materials	10,000
	Total @ 1980	67,000
	Total @ 1990	145,000

CREAMER & NOBLE, INC.

CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT _____ Project No. _____

_____ Date _____

OWNER _____ Sheet _____ OF _____

Alternative D
WTP in Springdale for Town

Estimate by _____

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Inlet Structure				50,000.00
2	10" Inlet Structure	L.F.	2,500	12.00	30,000.00
3	Treatment Plant (450 gpm)	L.S.			300,000.00
4	100,000 Equalization Pond	L.S.			50,000.00
5	Pump Station	L.S.			40,000.00
6	0.5 mg Reservoir	L.S.			125,000.00
7	Backwash Pond	L.S.			40,000.00
8	Water Rights	L.S.			100,000.00
	Subtotal				735,000.00
	25% Contingencies, Legal, Fiscal, Engineering				184,000.00
	TOTAL				$919,000.00

ALTERNATIVE "D"

Operation & Maintenance

Initial

1.	Salaries (1½ full time operators)	30,000
2.	Utilities	
	a. Treatment Plant	3,600
	b. Pump Station	2,000
3.	Chemicals	1,500
4.	Professional Maintenance	4,000
5.	Parts & Materials	5,000
	Total	46,000

1990

1.	Salaries (2 full time operators)	30,000
2.	Utilities	
	a. Treatment Plant	7,000
	b. Pump Station	4,000
3.	Chemicals	3,000
4.	Professional Maintenance	8,000
5.	Parts & Materials	8,000
	Total @ 1980	60,000
	Total @ 1990	130,000

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

ROJECT _____ Project No. _____

_____ Date _____

WNER _____ Sheet _____ OF _____

Alternative E

Estimate by _____

WTP in Springdale for Springdale and N.P.S.

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Inlet Structure	L.S.			50,000.00
2	10" Inlet line	L.F.	2,500	12.00	30,000.00
3	Treatment Plant (650 gpm)	L.S.			400,000.00
4	100,000 gal Equilization Reservoir	L.S.			50,000.00
5	Pump Station	L.S.			50,000.00
6	.5 Mg Reservoir	L.S.			125,000.00
7	1 MG Reservoir	L.S.			200,000.00
8	Back Wash Pond	L.S.			50,000.00
9	6" Pumpline-in Town	L.F.	1000	7.00	7,000.00
	Subtotal				962,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				241,000.00
	Subtotal				1,203,000.00
10	Water Rights	L.S.			100,000.00
	TOTAL				1,303,000.00

ALTERNATIVE E

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Total Annual Debt Service
1 30/70%	15,000	1,000	35,000			
2 30/70%	9,000	600	21,000			
3 30/70%	120,000	8,200	280,000			
4 30/70%	15,000	1,000	35,000			
5 30/70%	15,000	1,000	35,000			
6			125,000			
7 100/0%	200,000	10,000				
8 30/70%	15,000	1,000	35,000			
9			7,000			
Subtotal	389,000	22,800	573,000			
+25%	97,250	5,700	143,250			
10	30,000	750	70,000			
TOTAL	516,250	29,300	786,250	468,000	321,000	18,200

ALTERNATIVE "E"

Operation & Maintenance

Initial

1.	Salaries (2 full time)	40,000
2.	Utilities	
	a. Treatment Plant	4,000
	b. Pump Station Assuming 200 gpm for N.P.S. and 300 gpm for Town 180 days per year	10,000
3.	Chemicals	2,000
4.	Professional Maintenance	4,000
5.	Parts & Maintenance	5,000
	Total	65,000

1990

1.	Salaries	40,000
2.	Utilities	
	a. Treatment Plant	8,000
	b. Pump Station 200 gpm Park & 400 gpm Town	16,000
3.	Chemicals	5,000
4.	Professional Maintenance	8,000
5.	Parts & Materials	10,000
	Total @ 1980	85,000
	Total @ 1990	184,000

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

OJECT _____ Project No. _____

_____ Date _____

VNER _____ Sheet _____ OF _____

Alternative F

Estimate by _____

Hurricane Wells for N.P.S. and Town

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Drill and Equipment Well	L.S.			150,000.00
2	8" D.I. Pipeline to Springdale	L.F.	143,000	8.00	1144,000.00
3	Booster Pump Station	EA	2	30000.00	60,000.00
4	1,000,000 Reservoir				200,000.00
5	500,000 Reservoir				125,000.00
6	8" Line through Springdale	L.F.	16,000	8.00	128,000.00
	Subtotal				1,807,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				452,000.00
	Subtotal				2,259,000.00
7	Water Rights				100,000.00
	TOTAL				2,359,000.00

ALTERNATIVE F

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Total Annual Debt Service
1	45,000	3,100	105,000			
2	343,200	11,700	800,800			
3	18,000	1,200	42,000			
4	200,000	10,000				
5			125,000			
6	38,400	1,300	89,600			
Subtotal	644,600	27,300	1,162,400			
+25%	161,150	1,800	290,600			
7	30,000	750	70,000			
TOTAL	835,750	29,900	1,523,000	905,000	604,000	35,200

ALTERNATIVE "F"

Operation & Maintenance

Initial

1.	Salaries ¼ time operator	5,000
2.	Utilities	
	a. Pump Station Assumint TDH=1000 GPM=650 for 180 days	48,000
3.	Chemicals	
4.	Professional Maintenance	1,000
5.	Parts & Materials	3,000
	Total	57,000

1990

1.	Salaries	5,000
2.	Utilities	
	a. Pump Station	60,000
	b.	
3.	Chemicals	0
4.	Professional Maintenance	2,000
5.	Parts & Materials	4,000
	Total @ 1980	71,000
	Total @ 1990	154,000

CREAMER & NOBLE, INC.

CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT _____ Project No. _____

_____ Date _____

OWNER _____ Sheet _____ OF _____

Alternative G
Well Supply from Plains for N.P.S. & Town

Estimate by _____

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Wells (Drill & Equipment)	EA	2	80,000.00	160,000.00
2	12" D.I. Line to Crest	L.F.	10,000	12.00	120,000.00
3	8" D.I. Line (To Reservoir)	L.F.	18,000	10.00	180,000.00
4	1. mg Reservoir	L.S.			200,000.00
5	8" D.I. Line (to Park Boundary)	L.F.	38,000	10.00	380,000.00
6	River Crossing	EA			30,000.00
7	0.5 mg Reservoir	L.S.	1		125,000.00
8	Generator				100,000.00
	Subtotal				1,295,000.00
	25%Engineering Legal, Fiscal				324,000.00
					1,619,000.00
9	Water Rights	L.S.			50,000.00
	TOTAL				1,669,000.00

ALTERNATIVE G

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Town Annual Debt Service
1	48,000	1,600	112,000			
2	36,000	1,200	84,000			
3	54,000	1,800	126,000			
4	200,000					
5	114,000	3,900	266,000			
6	9,000	300	21,000			
7			125,000			
8	30,000	2,100	70,000			
Subtotal	491,000	10,900	804,000			
+25%	122,750	2,700	201,000			
9	15,000	375	35,000			
TOTAL	628,750	14,000	1,040,000	578,400	385,600	22,500

ALTERNATIVE "G"

Operation & Maintenance

Initial

1.	Salaries (¼ time operator)	5,000
2.	Utilities	
	a.	
	b.	
3.	Chemicals	1,500
4.	Professional Maintenance	3,000
5.	Parts & Materials	2,000
	Total	11,500

1990

1.	Salaries	5,000
2.	Utilities	
	a.	
	b.	
3.	Chemicals	3,000
4.	Professional Maintenance	3,000
5.	Parts & Materials	3,000
	Total @ 1980	12,500
	Total @ 1990	27,200

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park Water — Project No.

Alternative H — Date

OWNER — Sheet ___ OF ___

Well Supply from Plains for Town Only — Estimate by

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Well	EA	1	80,000.00	80,000.00
2	8" D.I. Pipe	L.F.	10,000	10.00	100,000.00
3	6" D.I. Pipe	L.F.	18,000	7.00	126,000.00
4	0.5 MG Reservoir	L.S.			125,000.00
5	6" D.I. Pipe	L.F.	23,000	7.00	161,000.00
6	River Crossing				30,000.00
7	Generator				100,000.00
	Subtotal				722,000.00
	25% Contingencies, Legal, Fiscal, Engineering Fees				180,500.00
8	Water Rights				25,000.00
	TOTAL				928,000.00

ALTERNATIVE "H"

Operation & Maintenance

Initial

1.	Salaries	4,000
2.	Utilities	
	a.	
	b.	
3.	Chemicals	1,000
4.	Professional Maintenance	2,000
5.	Parts & Materials	1,000
	Total	8,000

1990

1.	Salaries	4,000
2.	Utilities	
	a.	
	b.	
3.	Chemicals	2,000
4.	Professional Maintenance	2,500
5.	Parts & Materials	2,000
	Total @ 1980	9,000
	Total @ 1990	19,500

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park Water

Alternative I

OWNER

Well Supply from Shunesburg for National Park Service and Town

Project No

Date May 9, 1980

Sheet OF

Estimate by

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Well (Drill & Equipment)	L.S.			60,000.00
2	Power Supply (for pumps)	L.S.			50,000.00
3	Chlorine Treatment Plant	L.S.			10,000.00
4	Preliminary Exploration	L.S.			10,000.00
5	Rough Grading	L.S.			25,000.00
6	8" D.I. Pipe (well to reservoir)	L.F.	13,700	12.00	164,400.00
7	(Reservoir to) 8" D.I. Pipe (Park Headquarters)	L.F.	22,700	10.00	227,000.00
8	River Crossing	Each	2	25,000.00	50,000.00
9	Reservoir 1 million gallon (NPS)	LS			200,000.00
10	Reservoir .5 million gallon (Town)	LS			125,000.00
	Subtotal				921,400.00
	25% Contingencies, Engineering,	Legal,	Fiscal		230,400.00
	TOTAL			*	1,151.800.00
*	Cost does not include water rights;				
	valid estimates not currently available.				

ALTERNATIVE I

Cost Breakdown

Item #	N.P.S. Share	N.P.S. Annual Depreciation	Town Share	Town Grant	Town Loan	Total Annual Debt Service
1	18,000	1,200	42,000			
2	15,000	1,700	35,000			
3	3,000	200	7,000			
4	3,000	200	7,000			
5	7,500	800	17,500			
6	49,000	1,600	115,100			
7	68,100	2,300	158,900			
8	15,000	500	35,000			
9	200,000	5,000				
10			125,000			
Subtotal	378,600	13,500	542,500			
+25%	95,000	3,400	135,625			
TOTAL	473,600	16,900	678,125	388,100	258,800	15,100

ALTERNATIVE "I"

Operation & Maintenance

Initial

1.	Salaries (¼ time operator)	5,000
2.	Utilities	
	a. Pump Station Assuming 200 gpm each for N.P.S. and Town 180 days per year	10,100
3.	Chemicals	1,500
4.	Professional Maintenance	3,000
5.	Parts & Materials	2,000
	Total	21,600

1990

1.	Salaries	9,500
2.	Utilities	
	a. Pump Station Assuming 400 gpm each for N.P.S. and Town 180 days per year	47,500
3.	Chemicals	3,000
4.	Professional Maintenance	5,700
5.	Parts & Materials	3,800
	Total @ 1980	21,600
	Total @ 1990	69,500

CREAMER & NOBLE, INC.
CONSULTING ENGINEERS

Engineer's Preliminary Estimate

PROJECT Springdale - Zion National Park Water — Project No.

Alternative J — Date May 9, 1980

OWNER — Sheet ___ OF ___

Well Supply from Shunesburg for Springdale Only — Estimate by

Item No.	ITEM	Unit	Quantity	Unit Price	Amount
1	Well (Drill & Equipment)	L.S.			60,000.00
2	Power Supply (for pumps)	L.S.			50,000.00
3	Chlorine Treatment Plant	L.S.			10,000.00
4	Preliminary Exploration	L.S.			10,000.00
5	Rough Grading	L.S.			25,000.00
6	8" D.I. Pipe (well to reservoir)	L.F.	13,700	12.00	164,400.00
8	River Crossing	Each	2	25,000.00	50,000.00
9	Reservoir	LS			200,000.00
	Subtotal				569,400.00
	25% Contingencies, Engineering,	Legal	Fiscal		142,350.00
	TOTAL			*	711,750.00

* **Cost does not include water rights; valid estimates not currently available.**

ALTERNATIVE "J"

Operation & Maintenance

Initial

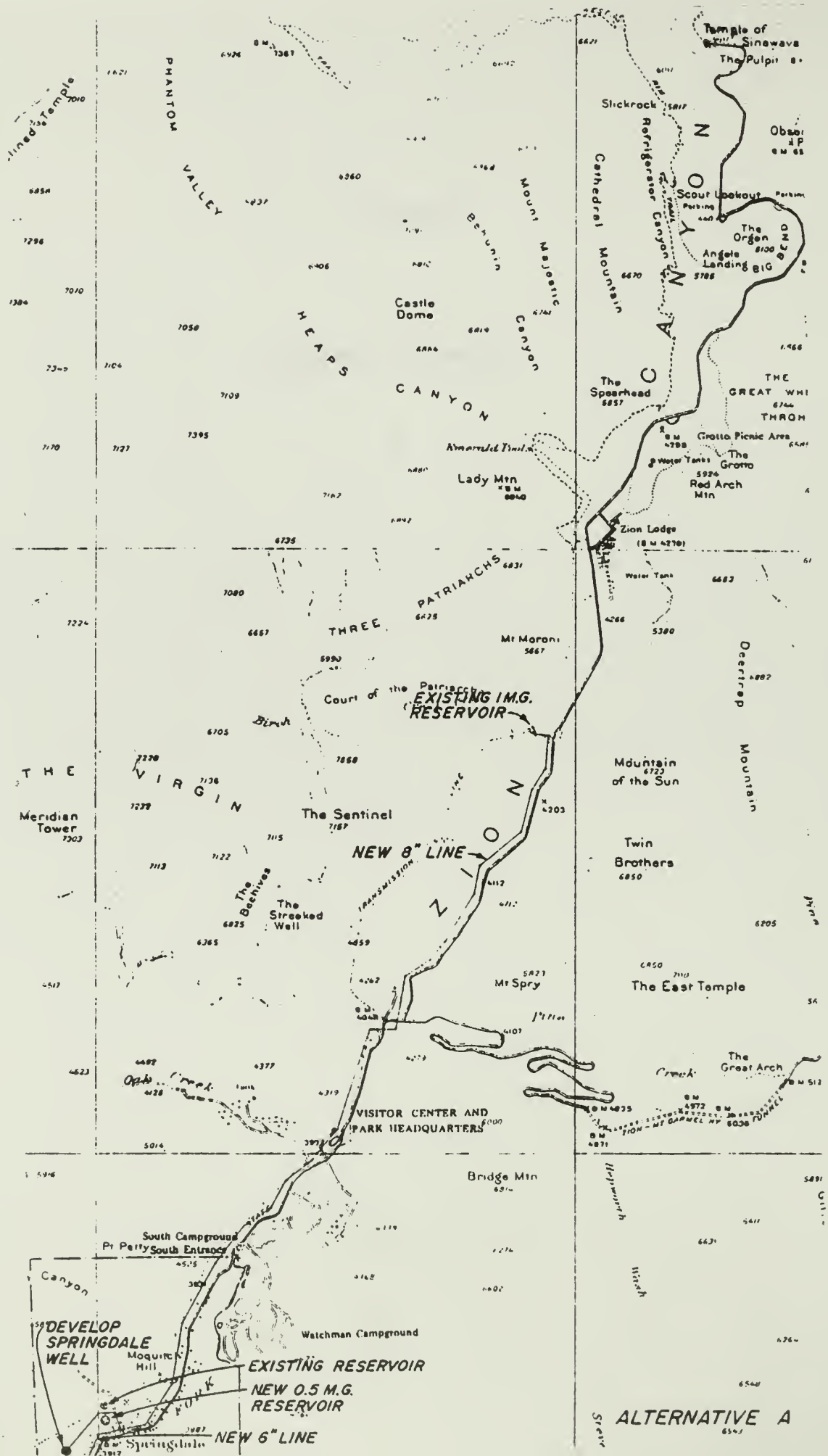
1.	Salaries (¼ time operator)	5,000
2.	Utilities	
	a. Pump Station Assuming 200 gpm each for N.P.S. and Town 180 days per year	10,100
3.	Chemicals	1,500
4.	Professional Maintenance	3,000
5.	Parts & Materials	2,000
	Total	21,600

1990

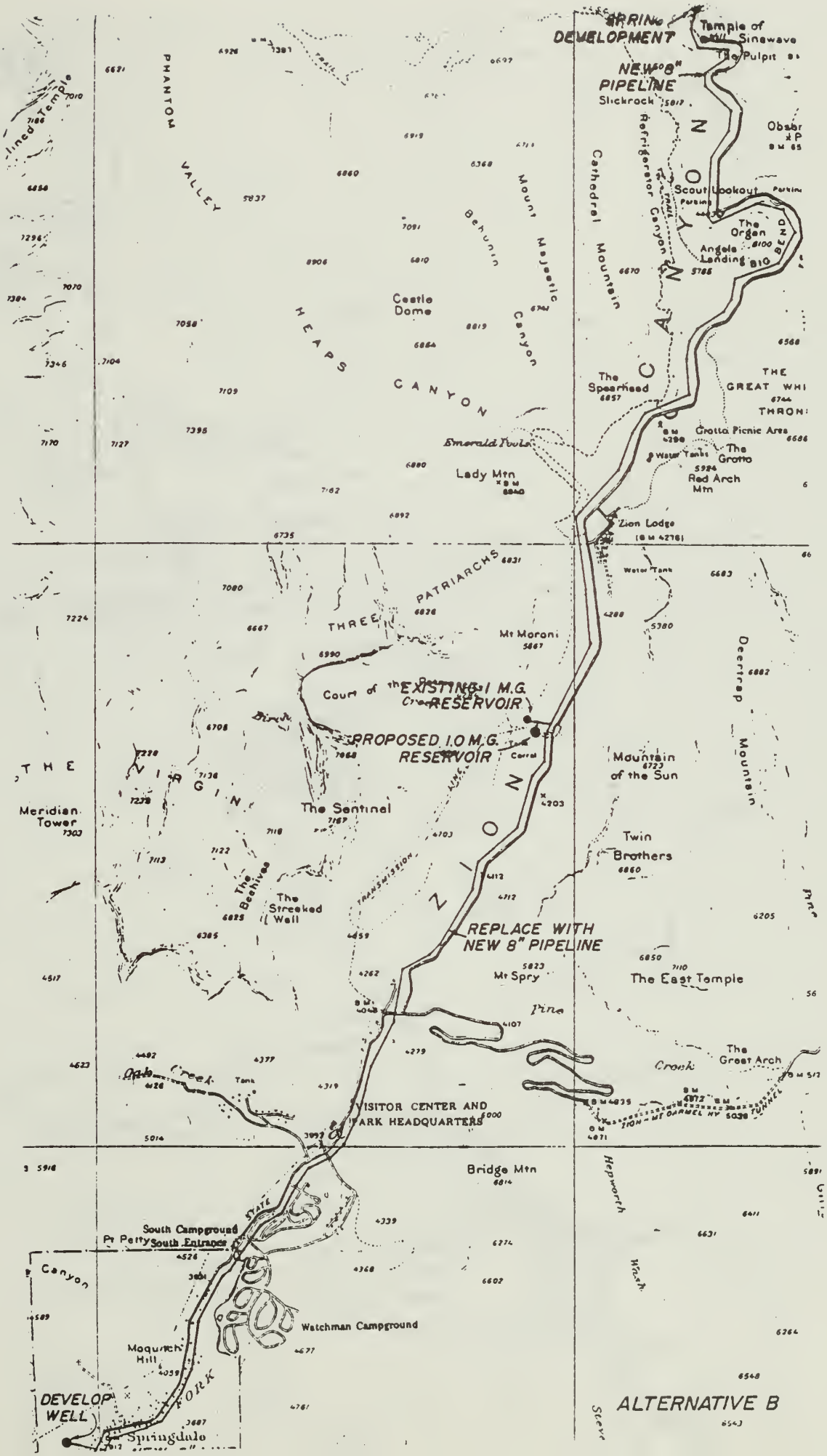
1.	Salaries	9,500
2.	Utilities	
	a. Pump Station Assuming 400 gpm each for N.P.S. and Town 180 days per year	47,500
3.	Chemicals	3,000
4.	Professional Maintenance	5,700
5.	Parts & Materials	3,800
	Total @ 1980	21,600
	Total @ 1990	69,500

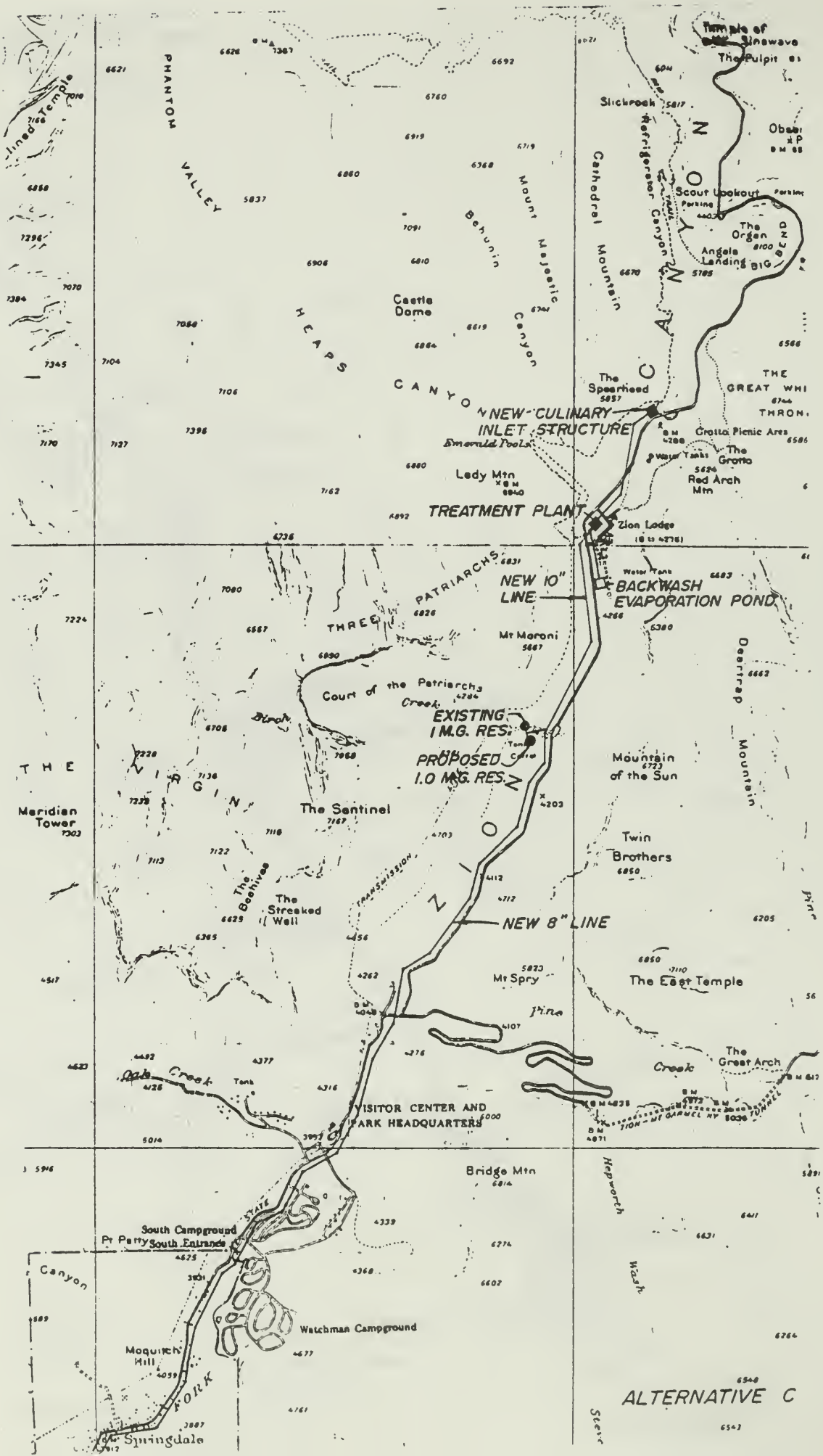
APPENDIX E

ALTERNATIVE SITE MAPS

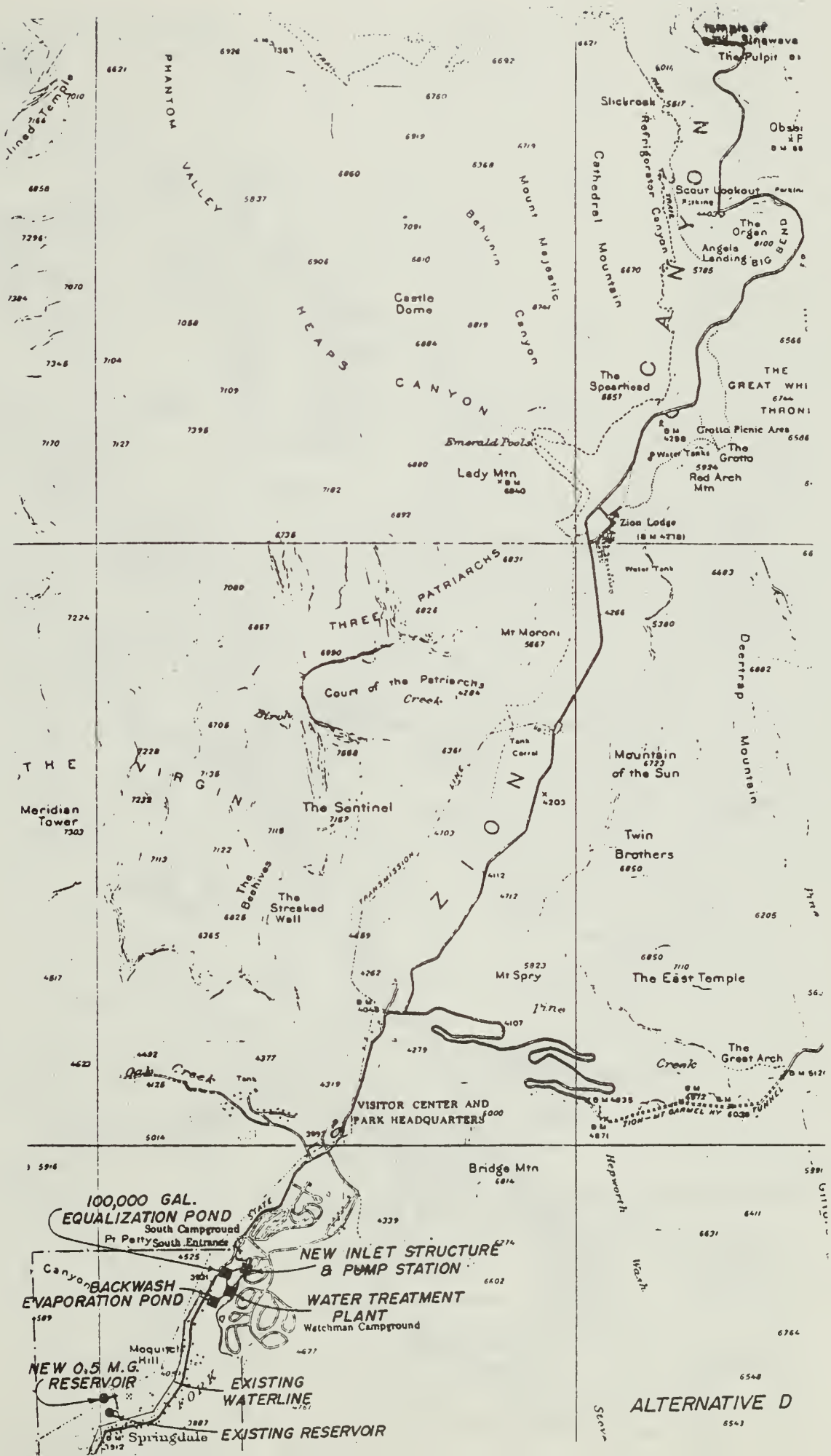


Temple of Sinewave
The Pulpit
Slickrock
Refrigerator Canyon
Cathedral Mountain
Scout Lookout
The Organ
Angels Landing
BIG BEND
PHANTOM VALLEY
Mount Majestic
Behunin Canyon
Castle Dome
HEAPS CANYON
The Spearhead
THE GREAT WHI
THROH
Grotto Picnic Area
The Grotto
Red Arch Mtn
Lady Mtn
Zion Lodge
THREE PATRIARCHS
Mt Moroni
Court of the Patriarchs
EXISTING 1 M.G. RESERVOIR
Deertrap Mountain
Mountain of the Sun
THE VIRGIN
Meridian Tower
The Sentinel
NEW 8" LINE
Twin Brothers
The Beehives
The Streaked Well
ZION
Mt Spry
The East Temple
The Great Arch
Oak Creek
VISITOR CENTER AND PARK HEADQUARTERS
Bridge Mtn
South Campground
Pt Petty
South Entrance
Canyon
DEVELOP SPRINGDALE WELL
Moquitch Hill
Watchman Campground
EXISTING RESERVOIR
NEW 0.5 M.G. RESERVOIR
NEW 6" LINE
Springdale
ALTERNATIVE A

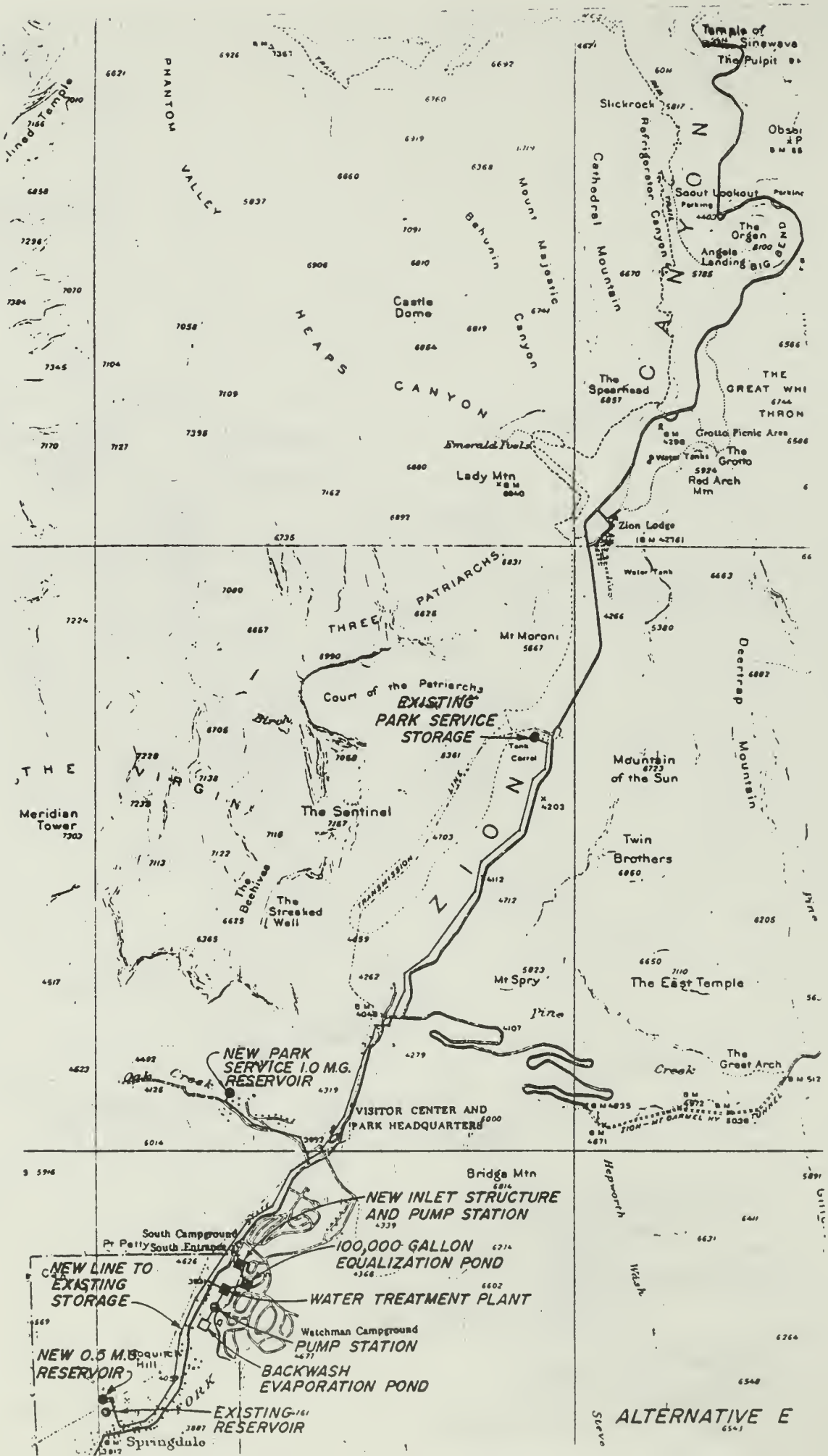

SPRING DEVELOPMENT
Temple of Sinawava
The Pulpit
NEW 8" PIPELINE
Slickrock
Refrigerator Canyon
Cathedral Mountain
Scout Lookout
The Organ
Angels Landing
PHANTOM VALLEY
Mount Majestic
Behunin Canyon
Castle Dome
HEAPS CANYON
The Spearhead
THE GREAT WHITE THRONE
Grotto Picnic Area
The Grotto
Red Arch Mtn
Emerald Pools
Lady Mtn
Zion Lodge
THREE PATRIARCHS
Mt Moroni
Court of the Patriarchs
EXISTING 1 M.G. RESERVOIR
PROPOSED 1.0 M.G. RESERVOIR
Deertrap Mountain
Mountain of the Sun
THE VIRGIN
Meridian Tower
The Sentinel
Twin Brothers
The Beehives
The Streaked Wall
TRANSMISSION LINE
REPLACE WITH NEW 8" PIPELINE
Mt Spry
The East Temple
Pine Creek
The Great Arch
VISITOR CENTER AND PARK HEADQUARTERS
Bridge Mtn
Hepworth Wash
South Campground
Pt Petty
South Entrance
Canyon
Watchman Campground
Moquith Hill
DEVELOP WELL
FORK
Springdale
ALTERNATIVE B



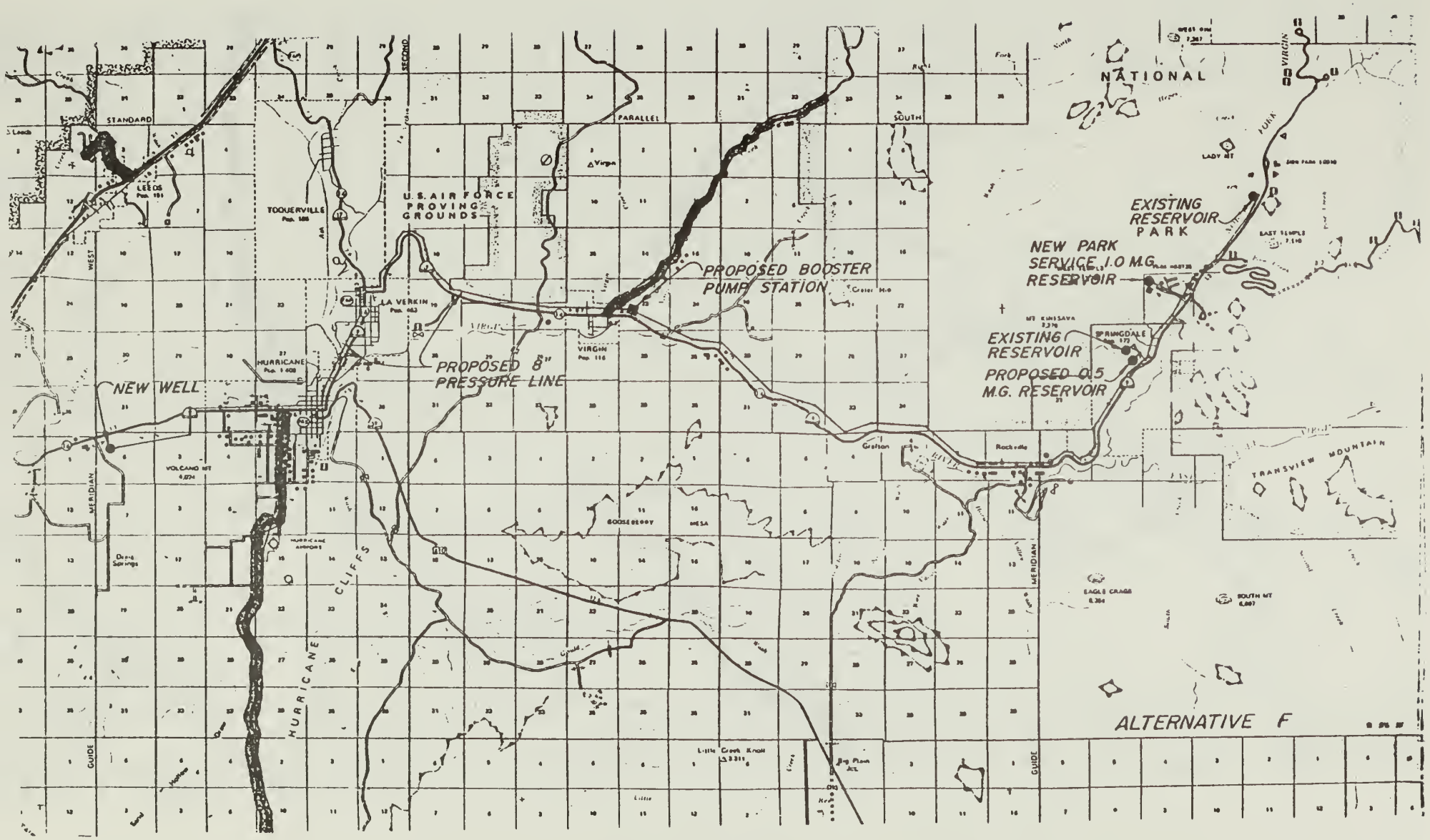
NEW CULINARY INLET STRUCTURE
TREATMENT PLANT
NEW 10" LINE
BACKWASH EVAPORATION POND
EXISTING 1 M.G. RES.
PROPOSED 1.0 M.G. RES.
NEW 8" LINE
VISITOR CENTER AND PARK HEADQUARTERS
South Campground
South Entrance
Watchman Campground
Zion Lodge
Scout Lookout
The Organ
Angels Landing
The Spearhead
Grotto Picnic Area
The Grotto
Red Arch Mtn
Lady Mtn
Castle Dome
Mount Majestic
Behunin Canyon
Cathedral Mountain
Refrigerator Canyon
Slickrock
The Pulpit
Sinewave
Emerald Pools
Mt Moroni
Court of the Patriarchs
Birch Creek
The Sentinel
The Beehives
The Streaked Wall
Meridian Tower
Mountain of the Sun
Twin Brothers
Deertrap Mountain
Mt Spry
The East Temple
The Great Arch
Pine Creek
Oak Creek
Bridge Mtn
Hepworth Wash
Moquitch Hill
Springdale
Canyon
PHANTOM VALLEY
HEAPS CANYON
THREE PATRIARCHS
THE VIRGIN
ZION CANYON
ALTERNATIVE C

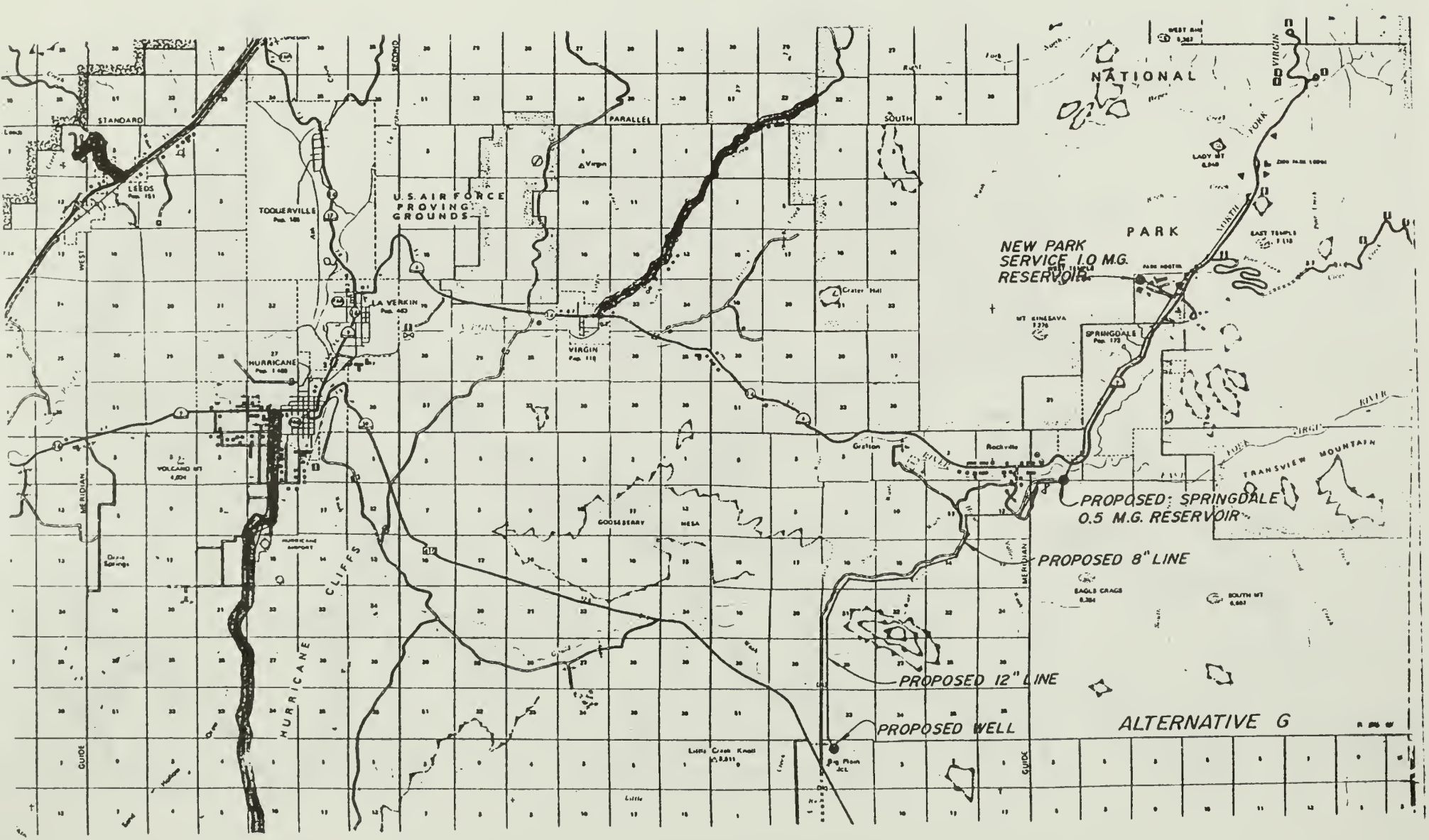


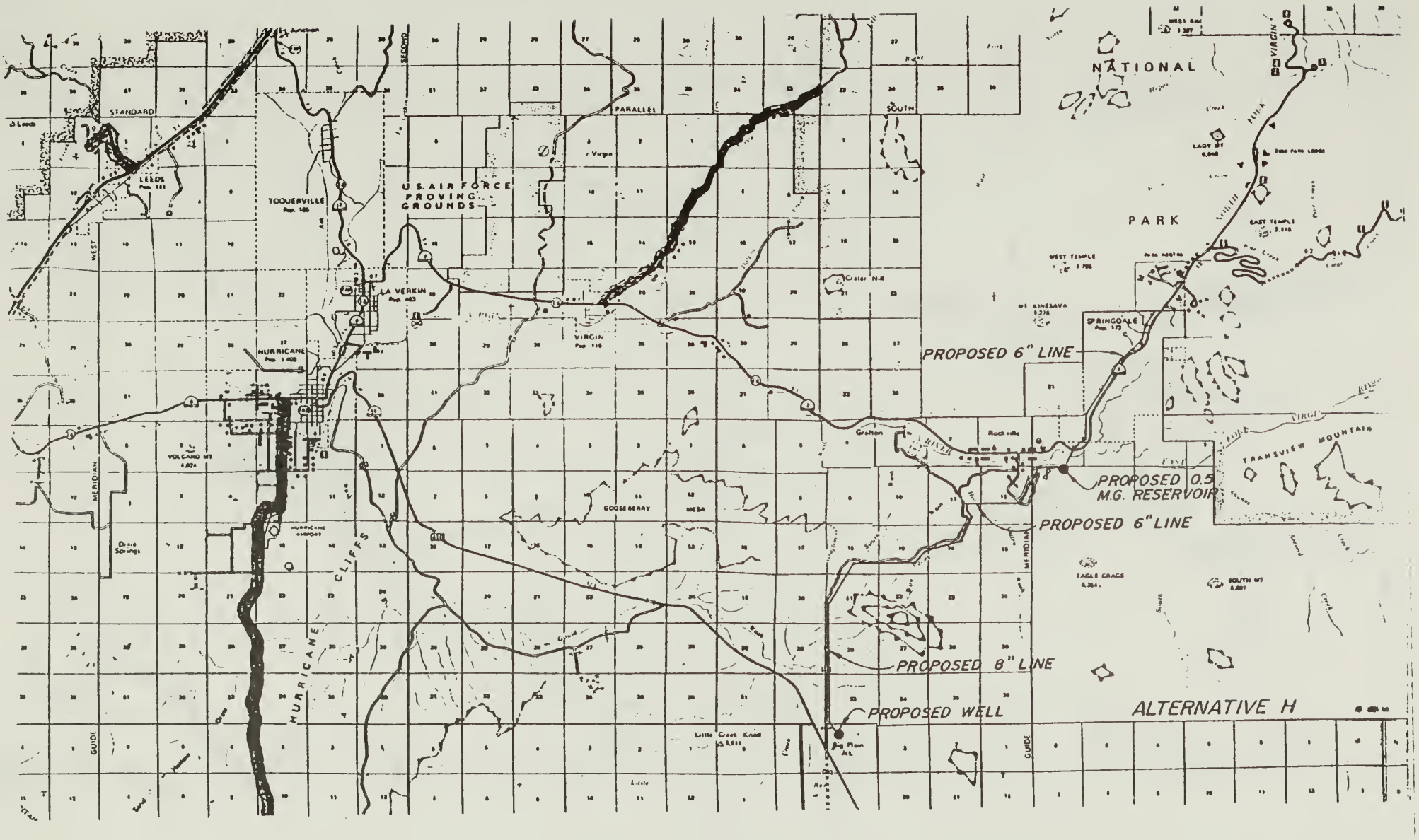
PHANTOM VALLEY
HEAPS CANYON
Castle Dome
Mount Majestic
Behunin Canyon
Cathedral Mountain
Refrigerator Canyon
Slickrock
The Pulpit
Scout Lookout
The Organ
Angels Landing
BIG BEND
The Spearhead
THE GREAT WHI
THRONI
Grotto Picnic Area
The Grotto
Red Arch Mtn
Emerald Pools
Lady Mtn
Zion Lodge
THREE PATRIARCHS
Mt Moroni
Court of the Patriarchs
Creek
Deertrap Mountain
Mountain of the Sun
THE VIRGIN
Meridian Tower
The Sentinel
Twin Brothers
The Beehives
The Streaked Wall
ZION
Mt Spry
The East Temple
Pine Creek
The Great Arch
Oak Creek
VISITOR CENTER AND PARK HEADQUARTERS
Bridge Mtn
Hepworth Wash
100,000 GAL. EQUALIZATION POND
South Campground
Pt Petty
South Entrance
NEW INLET STRUCTURE & PUMP STATION
BACKWASH EVAPORATION POND
WATER TREATMENT PLANT
Watchman Campground
Moquitch Hill
NEW 0.5 M.G. RESERVOIR
EXISTING WATERLINE
EXISTING RESERVOIR
Springdale
ALTERNATIVE D

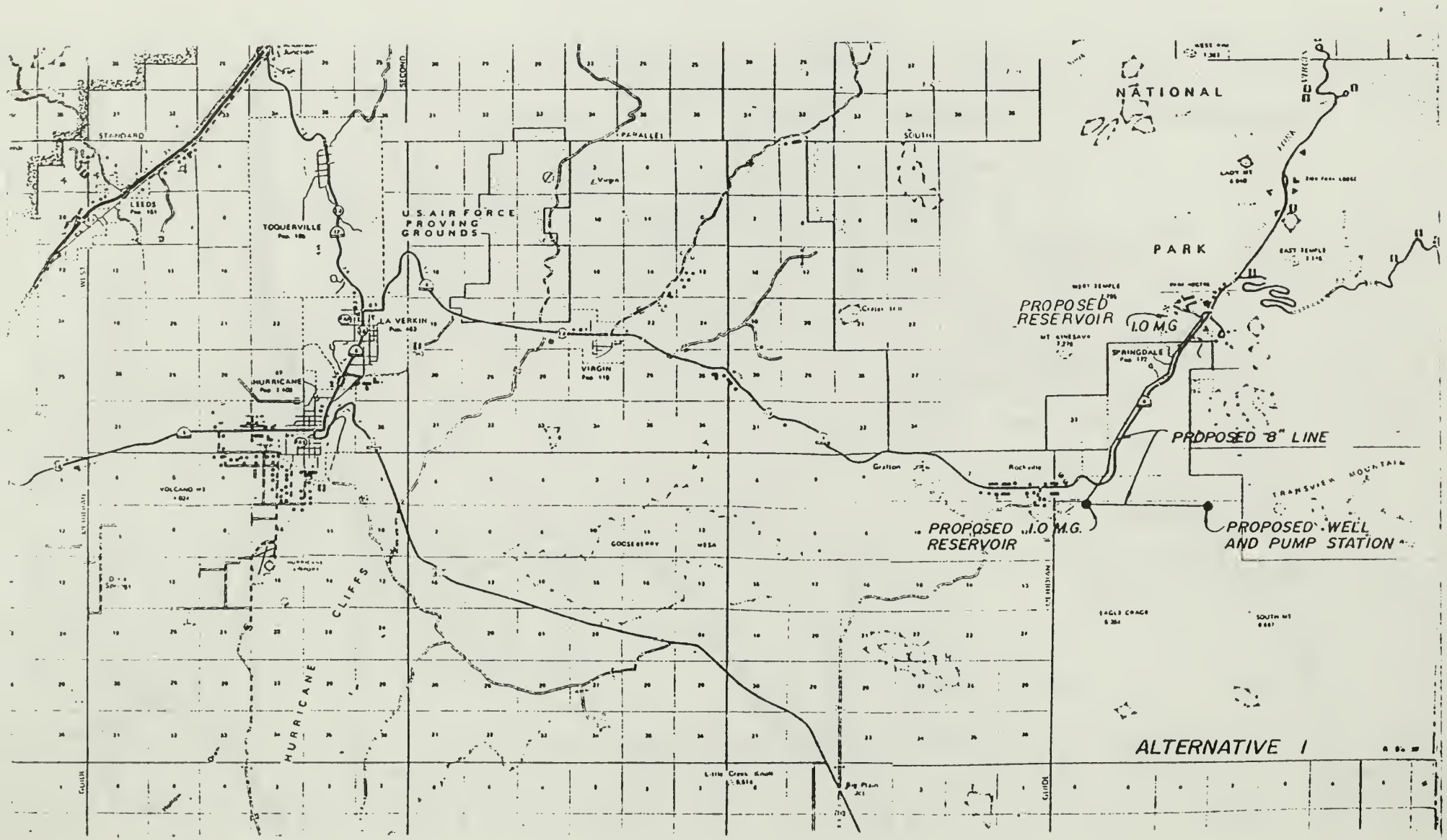


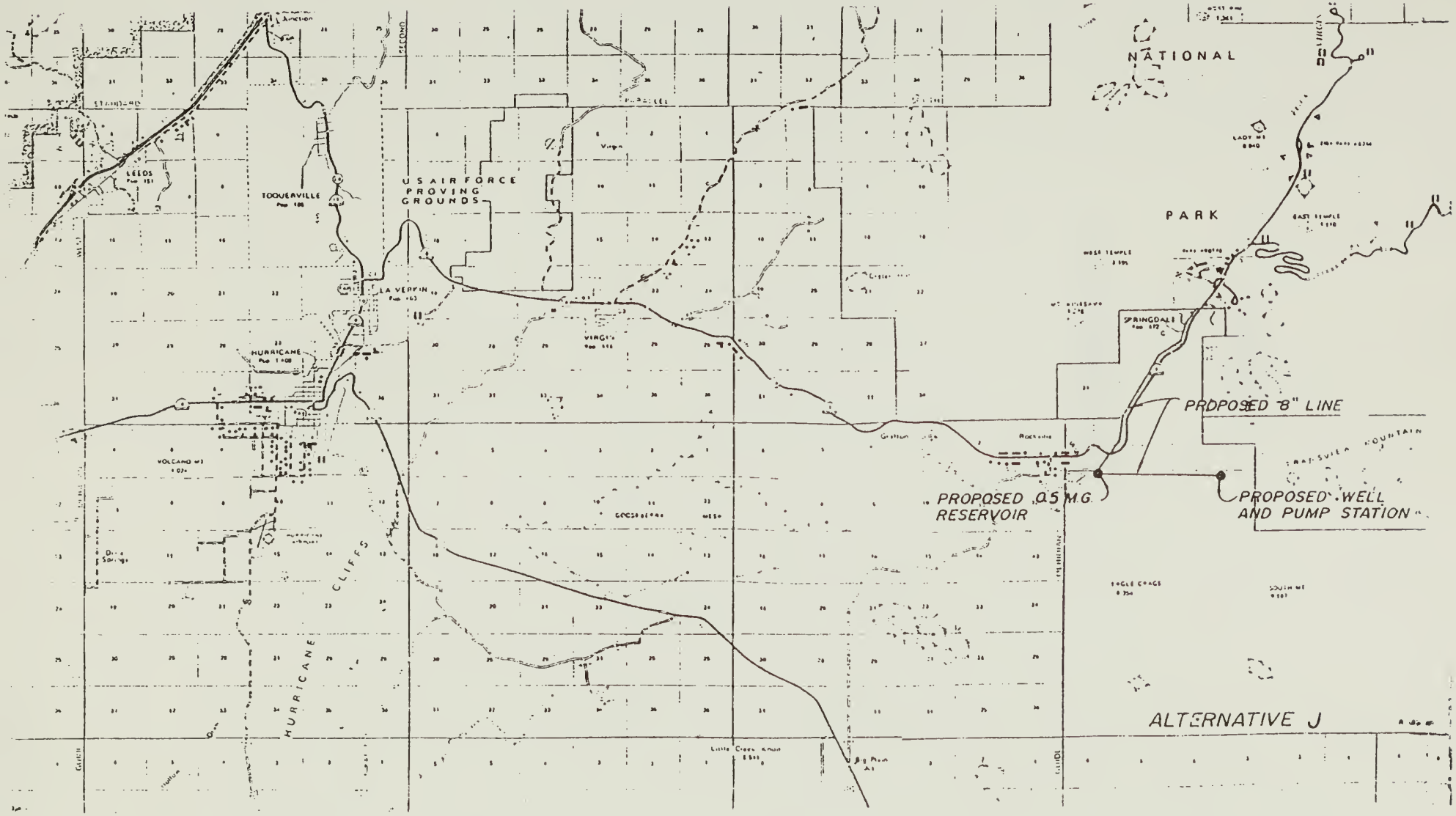
Temple of Sinewave
The Pulpit
Slickrock
Refrigerator Canyon
Cathedral Mountain
Scout Lookout
The Organ
Angels Landing
BIG BEND
PHANTOM VALLEY
Mount Majestic
Bahunin Canyon
Castle Dome
HEAPS CANYON
The Spearhead
THE GREAT WHI THRON
Grotto Picnic Area
The Grotto
Red Arch Mtn
Emerald Pools
Lady Mtn
Zion Lodge
THREE PATRIARCHS
Mt Moroni
Court of the Patriarchs
EXISTING PARK SERVICE STORAGE
Deertrap Mountain
Mountain of the Sun
THE VIRGIN
Meridian Tower
The Sentinel
Twin Brothers
The Beehives
The Streaked Wall
ZION
Mt Spry
The East Temple
Pine Creek
The Great Arch
NEW PARK SERVICE 1.0 M.G. RESERVOIR
Oak Creek
VISITOR CENTER AND PARK HEADQUARTERS
Bridge Mtn
NEW INLET STRUCTURE AND PUMP STATION
South Campground
Pt Petty
South Entrance
100,000 GALLON EQUALIZATION POND
NEW LINE TO EXISTING STORAGE
WATER TREATMENT PLANT
Watchman Campground
PUMP STATION
NEW 0.5 M.G. RESERVOIR
BACKWASH EVAPORATION POND
EXISTING RESERVOIR
Springdale
Hepworth Wash
ALTERNATIVE E


NATIONAL
STANDARD
TOQUERVILLE
U.S. AIR FORCE PROVING GROUNDS
LA VERKIN
HURRICANE
VIRGIN
PARALLEL
SOUTH
SECOND
WEST
MERIDIAN
GUIDE
VIRGIN
FORK
EXISTING RESERVOIR PARK
NEW PARK SERVICE 1.0 M.G. RESERVOIR
PROPOSED BOOSTER PUMP STATION
EXISTING RESERVOIR
PROPOSED 0.5 M.G. RESERVOIR
PROPOSED 8" PRESSURE LINE
NEW WELL
HURRICANE CLIFFS
Rockville
Grafton
TRANSVIEW MOUNTAIN
ALTERNATIVE F


NATIONAL
PARK
NEW PARK SERVICE 1.0 M.G. RESERVOIR
PROPOSED SPRINGDALE 0.5 M.G. RESERVOIR
PROPOSED 8" LINE
PROPOSED 12" LINE
PROPOSED WELL
ALTERNATIVE G
U.S. AIR FORCE PROVING GROUNDS
HURRICANE CLIFFS
TRANSVIEW MOUNTAIN
STANDARD
PARALLEL
SOUTH
LEEDS
TOQUERVILLE
LA VERKIN
HURRICANE
VIRGIN
SPRINGDALE
Rockville
Grafton
GOOSEBERRY MESA
VOLCANO MT
EAGLE CRAGS
SOUTH MT
LADY MT
EAST TEMPLE
MT KINESAVA
Crater Hill
Little Creek Knoll
Big Plain Jct.
WEST
MERIDIAN
GUIDE
SECOND
NORTH FORK
VIRGIN
RIVER


NATIONAL
PARK
U.S. AIR FORCE
PROVING
GROUNDS
STANDARD
LEEDS
TOQUERVILLE
LA VERKIN
HURRICANE
VIRGIN
SPRINGDALE
Rockville
Grafton
GOOSEBERRY
MESA
HURRICANE
CLIFFS
TRANSVIEW MOUNTAIN
PROPOSED 6" LINE
PROPOSED 0.5
M.G. RESERVOIR
PROPOSED 6" LINE
PROPOSED 8" LINE
PROPOSED WELL
ALTERNATIVE H
SECOND
PARALLEL
SOUTH
WEST
MERIDIAN
GUIDE
VIRGIN


NATIONAL
PARK
PROPOSED RESERVOIR
1.0 M.G
PROPOSED 8" LINE
PROPOSED 1.0 M.G. RESERVOIR
PROPOSED WELL AND PUMP STATION
ALTERNATIVE 1
U.S. AIR FORCE PROVING GROUNDS
TOQUERVILLE
LA VERKIN
HURRICANE
VIRGIN
LEEDS
SPRINGDALE
HURRICANE CLIFFS
STANDARD
SECOND
PARALLEL
SOUTH
WEST
GOOSEBERRY MESA
TRANSVIEW MOUNTAIN
EAGLE CRAGE
SOUTH MT
Rockville
Gratton
Virgin
Junction


NATIONAL
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GROUNDS
TOQUERVILLE
LA VERKIN
HURRICANE
VIRGIN
SPRINGDALE
LEEDS
VOLCANO MT
HURRICANE CLIFFS
PROPOSED 8" LINE
PROPOSED .05 M.G.
RESERVOIR
PROPOSED WELL
AND PUMP STATION
ALTERNATIVE J

APPENDIX F

SPECIAL DIRECTIVE 78-2

United States Department of the Interior

NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

Memorandum

Annual Review

SPECIAL DIRECTIVE 78-2

To: Field Directorate and all Park Superintendents

From: Director

Subject: Sale or lease of services, resources, or water available within an area of the National Park System

Section 3(e) of Public Law 91-383, 84 Stat 827, authorizes the Secretary to enter into contracts which provide for the sale or lease to persons, States or their political subdivisions, of services, resources, or water available within an area of the National Park System if such person, State or its political subdivision:

1. Provides public accommodations or services within the immediate vicinity of an area of the National Park System to persons visiting the area; and

2. Has demonstrated to the Secretary that there are no reasonable alternatives by which to acquire or perform the necessary services, resources, or water.

On the basis of the Assistant Solicitor's comments and findings, which are applicable Serivcewide, see enclosed February 2, 1978 memorandum, relative to Public Law 91-383, the November 24, 1970 "Standards for Implementation" memorandum signed by former Director Hartzog is hereby rescinded. The revised standards for implementation of New Authorities under Public Law 91-383 are as follows:

In the granting of permits for services, resources or water, the Directors of the Regions will have exercised this authority satisfactorily when the following conditions have been met:

1. The services provided by the applicant are of direct benefit to the park, or to the National Park Service for the direct or indirect benefit of park visitors;

2. It has been determined that the applicant has no reasonable alternative to the use of park resources or services;

3. Effects of use of the resource or service on the park's environment, administration, management and protection, and visitors have been examined and these effects have been determined to be acceptable. The environmental impacts of the use or service will be assessed and an environmental impact statement prepared if required according to NPS Guidelines for Environmental Assessment and Statements;

4. When it is determined that use of water by the applicant will be in accordance with laws and regulations governing ownership and use of Federal water and rights;

5. Charges have been established for services, resource or water use that permit recovery of the full cost to the government of providing the services, resource or water use in accord with 31 U.S.C. 483 a and OMB Circular A-25;

6. An application docket containing a draft of the special use permit, background materials and recommendations has been received by the Washington Office for submission to appropriate congressional committees for review and concurrence prior to consummating any legally or morally binding commitments. The application docket should reflect multi-disciplinary regional involvement and clearance of the proposed application.

7. The permitted use is for a short term period (one year or less) and is revocable at the discretion of the Secretary at any time without compensation and no permanent property rights are conveyed to the user for any resource or water within an area of the National Park Service. Water use agreements provide for National Park Service review and approval of planned development by the applicant that would create increased water demands.

should be emphasized, that while Public Law 91-383 conditionally allows the Secretary of Interior to authorize the sale of services, resources or park water, the Secretary's primary commitment, as mandated by the Congress, is the preservation and protection of National Park System resources which includes the conservation of System area water resources and related water dependent environment. In this regard, Service management policy limits water development and use, assuming no adverse impact on the natural environment, to the minimum required to

meet visitor and employee water needs. In essence, water is a vital part of the park environment and a natural resource the Service is committed to protect and in reality cannot be "excess" or "wasted" water, as viewed by some applicants.

Enclosure

APPENDIX G

SPRINGDALE WELL INFORMATION

850-18

Ford Chemical LABORATORY, INC.

Bacteriological and Chemical Analysis

40 WEST LOUISE AVENUE
SALT LAKE CITY, UTAH 84115
PHONE 485-5761

Lab. Sample No. 70
F - 788556

Date Analysis Started 4-14-78 Date Received 4-14-78

Date Collected 04/12/78 (mo. dy yr. 714)
Time Collected 1330 (610)
Water Syst. No. 27017 (703)
Source No. 002 (704)
Water Rights No. (707)
Supply Owned by SPRINGDALE TOWN (712)
River Mile Code (706) Mod (711) Township (716) Range (720) Section (721) QTRSC (726) QTRQTR (705)
Sample Collected by ENGLISH WILLIAMS (713)
Exact Description of Sampling Point SPRINGDALE SOURCE NO 2 (646, 647, 710)
Name SEND REPORT TO: (715)
Address (648, 717)
Phone No. (718)
Flows CFS (659)

TYPE OF SOURCE TABLE
01 Spring, 02 Well, 03 Stream, 04 Lake, 06 Dist. syst., 07 Effluent, 08 Storm sewer, 15 Tunnel, 18 Artesian well, 19 Swimming pool, 14 Other

WATER USE TABLE
1. Culinary
2. Agriculture
3. Industrial
4. Other

709 Current 1
709 Proposed
719 Sample Source 02

COUNTY CODE TABLE
01 Beaver, 02 Box Elder, 03 Cache, 04 Carbon, 05 Daggett, 06 Davis, 07 Duchesne, 08 Emery, 09 Garfield, 10 Grand, 11 Iron, 12 Juab, 13 Kane, 14 Millard, 15 Morgan, 16 Piute, 17 Rich, 18 Salt Lake, 19 San Juan, 20 Sanpete, 21 Sevier, 22 Summit, 23 Tooele, 24 Uintah, 25 Utah, 26 Wasatch, 27 Washington, 28 Wayne, 29 Weber
611 County 27

CHEMICAL ANALYSIS

	mg/l	ug/l	
Arsenic		< 1	723
Barium		50	724
Boron		540	725
Cadmium		< 1	727
Calcium	100		728
Chromium		< 5	729
Chromium, Hex. as Cr		< 5	730
Copper		10	732
Iron		< 50	733
Iron, Total	< .05		755
Lead		< 5	734
Magnesium	31		737
Manganese		13	738
Mercury, Total		< 0.2	739
Nickel		< 5	740
Potassium	6		742
Selenium		< 1	743
Silver		6	744
Sodium	350		745
Zinc		11	749
Turbidity, as NTU		7	757
Specific Cond. @ 25° C, µ mhos/cm		2080	762

	mg/l	
Bicarbonate	398	758
Carbonate	< 1	760
Chloride	354	763
Fluoride	.57	765
Hydroxide	< .01	767
Nitrate as N	.26	605
Nitrite as N	< .01	606
Phosphorus, Ortho as P		607
Silica, dissolved as SiO_2	11	750
Sulfate	320	772
pH Units	7.5	782
TDS @ 180° C	1350	786
Phosphorus, Tot.		785
Surfactant as MBAS	.15	773
Total Alk. as $CaCO_3$	326	752
Total Hardness as $CaCO_3$	380	754

TOTAL METALS ANALYSIS

	mg/l	ug/l	
Arsenic			660
Barium			661
Cadmium			662
Chromium			663
Copper			664
Iron			755
Lead			665
Manganese			666

	ug/l	
Mercury		739
Nickle		667
Selenium		668
Silver		669
Zinc		670

FORD CHEMICAL LABORATORY, INC.

Rev. 1/77

UTAH STATE DIVISION OF HEALTH
BUREAU OF WATER QUALITY
CHEMICAL ANALYSIS

MAY 25 Rec'd

TC JUN 20 1978

Lab Sample No. C 780632

Lab. Sample No. 701 | Storet No. 702 | Date Collected 05 22 78 (mo. dy yr. 711) | Time Collected 610 | Water Syst. No. 703 | Source No. 704 | Water Rights No. 707

Supply Owned by: SPRINGDALE 712 | River Mile Code 706 | Mod. 711 | Township 716 | Range 720 | Section 721 | QTRSC 726 | QTRQT 705

Sample Collected by: JOHN MORGAN 713

Exact Description of Sampling Point: LOWER WELL 646 647 710

Name: SPRINGDALE CITY 715

SEND REPORT TO:

Address: PO BOX 267 648

SPRINGDALE 84767 717

Phone No. 718

Flows CFS 65

TYPE OF SOURCE TABLE	
01 Spring	15 Tunnel
02 Well	
03 Stream	18 Artesian well
04 Lake	
06 Dist syst	19 Swimming pool
07 Effluent	
08 Storm sewer	14 Other

719 Sample Source: 02

WATER USE TABLE
1. Culinary
2. Agriculture
3. Industrial
4. Other

708 Current
709 Proposed

COUNTY CODE TABLE	
01 Beaver	16 Piute
02 Box Elder	17 Rich
03 Cache	18 Salt Lake
04 Carbon	19 San Juan
05 Daggett	20 Sanpete
06 Davis	21 Sevier
07 Duchesne	22 Summit
08 Emery	23 Tooele
09 Garfield	24 Uintah
10 Grand	25 Utah
11 Iron	26 Wasatch
12 Juab	27 Washington
13 Kane	28 Wayne
14 Millard	29 Weber
15 Morgan	

611 County: 21

DISSOLVED CHEMICAL ANALYSIS

me/l	CATIONS	mg/l	ug/l	
—	Ammonia as N	< .01		722
	Arsenic		20	723
	Barium	<	500	724
	Boron	18.00		725
	Cadmium	<	50	727
1.20	Calcium	24.		728
	Chromium	<	100	729
	Chromium, Hex as Cr	<	20	730
	Copper	<	50	732
	Iron	<	100	733
	Lead	<	200	734
0.80	Magnesium	10		737
	Manganese	<	50	738
	Mercury, Total		<.1	739
	Nickel	<	200	740
0.15	Potassium	<5		742
	Selenium	<	05	743
	Silver	<	50	744
39.15	Sodium	900		745
	Zinc	<	50	749
41.3	TOTAL CATIONS	940		

me/l	ANIONS	mg/l	
	Bicarbonate	296	758
	Carbon Dioxide	2	759
	Carbonate	0	760
27.22	Chloride	965	763
4.86	CO_3 Solids	146	
	Fluoride	2.00	765
	Hydroxide	00	767
	Nitrate as N	005	605
	Nitrite as N	010	606
	Phosphorus, Ortho as P	024	607
	Silica, dissolved as SiO_2	13	750
13.85	Sulfate	665	772
459	TOTAL ANIONS	1791	
	GRAND TOTAL	2731	

Turbidity, as NTU	12	757
Sampling Depth, m		609
Specific Gravity		608
Specific Cond @ 25° C, µ mhos/cm	4610	762

pH	8.3	782
TDS @ 180° C	3000	786
Phosphorus, Tot.	~~.024~~	785
Surfactant as MBAS	< 003	773
Total Alk. as $CaCO_3$	243	752
Total Hardness as $CaCO_3$	1000	754
Iron, Total	020	755

TOTAL METALS ANALYSIS

CATIONS	mg/l	ug/l	
Arsenic			660
Barium			661
Cadmium			662
Chromium			663
Copper			664
Iron			755
Lead			665
Manganese			666

CATIONS	ug/l	
Mercury		739
Nickle		667
Selenium		668
Silver		669
Zinc		670

ANALYSIS APPROVED BY: [illegible]

NPS #1760